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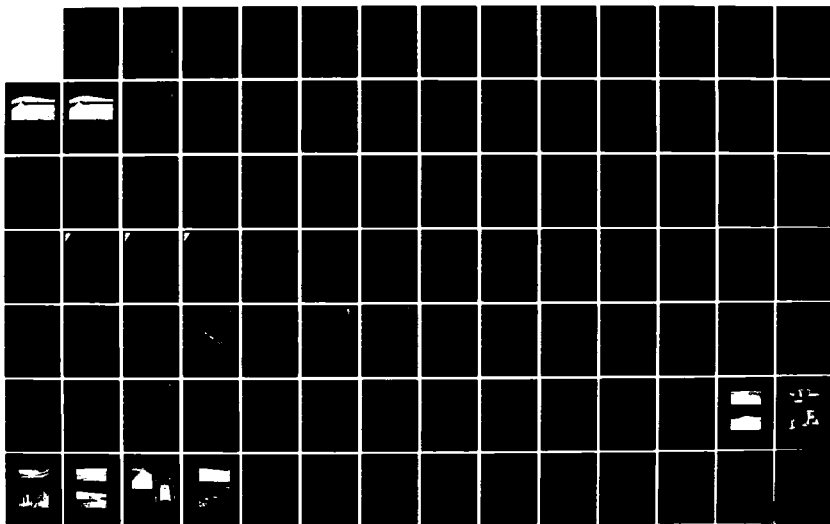
NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
PROVIN MOUNTAIN RESER. (U) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV JUN 81

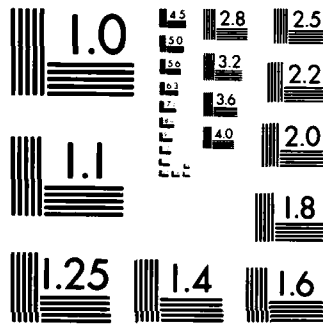
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

CONNECTICUT RIVER BASIN

AGAWAM, MASSACHUSETTS

AD-A155 398

PROVIN MOUNTAIN RESERVOIR

MA 00528

PHASE I INSPECTION REPORT NATIONAL DAM INSPECTION PROGRAM

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MA 00528	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Provin Mountain Reservoir NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS		8. CONTRACT OR GRANT NUMBER(s)
11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) DAMS, INSPECTION, DAM SAFETY, Connecticut River Basin Agawam, Massachusetts Off Stream		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This reservoir is a series of four concrete storage reservoirs, averaging 30 ft. deep. It is classified as small in size, having a high hazard potential. It is recommended that the Owner employ a qualified engineer to analyze the stability of Reservoir No.'s 1 and 2 under earthquake loading and present loading conditions, and to inspect the interior of all tanks.		



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:

NEDED

JUL 30 1981

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts 02133

Dear Governor King:

Inclosed is a copy of the Provin Mountain Reservoir (MA-00528) Phase I Inspection Report, prepared under the National Program for Inspection of Non-Federal Dams. This report is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. I approve the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is vitally important.

Copies of this report have been forwarded to the Department of Environmental Quality Engineering, and to the owner, City of Springfield, Springfield, MA. Copies will be available to the public in thirty days.

I wish to thank you and the Department of Environmental Quality Engineering for your cooperation in this program.

Sincerely,

C. E. EDGAR, III
Colonel, Corps of Engineers
Commander and Division Engineer

Incl
As stated

PROVIN MOUNTAIN RESERVOIR

MA 00528

CONNECTICUT RIVER BASIN
AGAWAM, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION
PROGRAM

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NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

BRIEF ASSESSMENT

Identification No: MA 00528

Name of Dam: Provin Mountain Reservoir

Town: Agawam

County and State: Hampden County, Massachusetts

Stream: Off Stream

Date of Inspection: March 4, 1981

Provin Mountain Reservoir is a series of four concrete storage reservoirs, averaging 30 feet deep, constructed on the ridge of Provin Mountain in Agawam, Massachusetts. Two of the concrete reservoirs are rectangular in shape and were constructed in 1910 and 1932, respectively. The first reservoir is 288 feet by 320 feet with a maximum height of 30 feet while the second reservoir is 288 feet by 224 feet with a maximum centerline depth of 38 feet. The two other concrete structures are circular and were added to the facility in 1958. These tanks are 29.5 feet in height and 320 feet in diameter. The total storage capacity of the four reservoirs is approximately 60 million gallons or 184 Acre-Feet. The structures are covered with earth and have stone paved side slopes. The facility serves as a distribution reservoir for the water supply system for the City of Springfield. The installation is maintained and operated by a full-time crew, one of which occupies a residence on the site. Inflow and outflow for the reservoirs is controlled by a system of valves. Overflow can be discharged through three separate 30-inch diameter pipes. Reservoir water levels and flows are continuously metered and are tied into a high and low water alarm system. Aerators are positioned over three of the tanks but are no longer used. The entire facility is in fair condition at the present time, pending examination of the tank interiors.

The following deficiencies were observed at the site: areas of localized sloughing in the rock slope of the east and west sides of Reservoir No. 1; minor creep with a tendency towards bulging in the lower half of the rock slopes of Reservoir No. 1; and seepage at the toe of the slope, northeast of Reservoir No. 2.

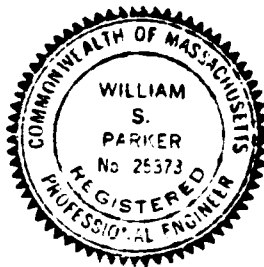
Since Provin Mountain Reservoir has a maximum centerline depth of 38 feet, a maximum wall height of 30 feet, and a storage capacity of 184 Acre-Feet, the reservoir has been classified in the "small" category based on both height and storage capacity. The hazard potential was determined by the downstream impact resulting from the failure of one wall on the rectangular tanks with a resultant

peak failure outflow of 66,300 cfs. The failure outflow would overtop two roadways and inundate two buildings at the dam site and two residential properties downstream. Thus, with appreciable economic loss, possible loss of more than a few lives and the loss of water supply, Provin Mountain Reservoir has been classified in the "high" hazard category.

It is recommended that the Owner employ a qualified Registered Professional Engineer to analyze the stability of Reservoir No's 1 and 2 under earthquake loading and present loading conditions, and to inspect the interior of all tanks. The Owner should put into effect any design modifications which may result from such studies. It is also recommended that the Owner implement a program of annual technical inspections with particular attention to any change in the quantity or clarity of seepage issuing from the ground to the northeast of Reservoir No. 2. The technical inspection should also include an inspection of the interior of all tanks. Other measures to be completed by the Owner include reshaping slumps in rock filled slopes, inspection of the tank interiors, monitoring seepage until engineering recommendations have been implemented, and monitoring bulges in westerly slope for major changes. Finally, an emergency preparedness plan should be developed for notifying downstream residents in the event of an emergency at the reservoir.

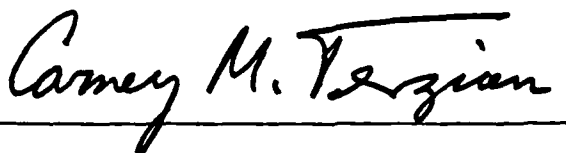
The measures outlined above and in Section 7 should be implemented by the Owner within a period of one year after receipt of this Phase I Inspection Report.

Cullinan Engineering Co., Inc.

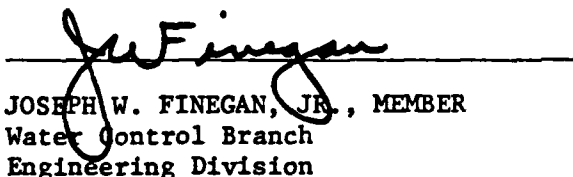


William S. Parker

This Phase I Inspection Report on Provin Mountain Reservoir (MA-00528) has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.



CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

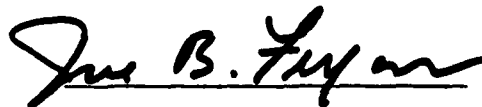


JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division



ARAMAST MAHTESIAN, CHAIRMAN
Geotechnical Engineering Branch
Engineering Division

APPROVAL RECOMMENDED:



JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in Recommended Guidelines for Safety Inspection of Dams, for a Phase I Investigation. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonable possible storm run-off), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

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OVERVIEW

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION
WALTHAM, MASSACHUSETTS

CULLINAN ENGINEERING CO., INC.
CIVIL ENGINEERS
AUBURN-BOSTON, MASSACHUSETTS

NATIONAL PROGRAM
OF INSPECTION
OF NON-FED. DAMS

Provin Mountain Reservoir
City of Springfield Aqueduct
Agawam, MA
MA 00528
March 4, 1981



OVERVIEW

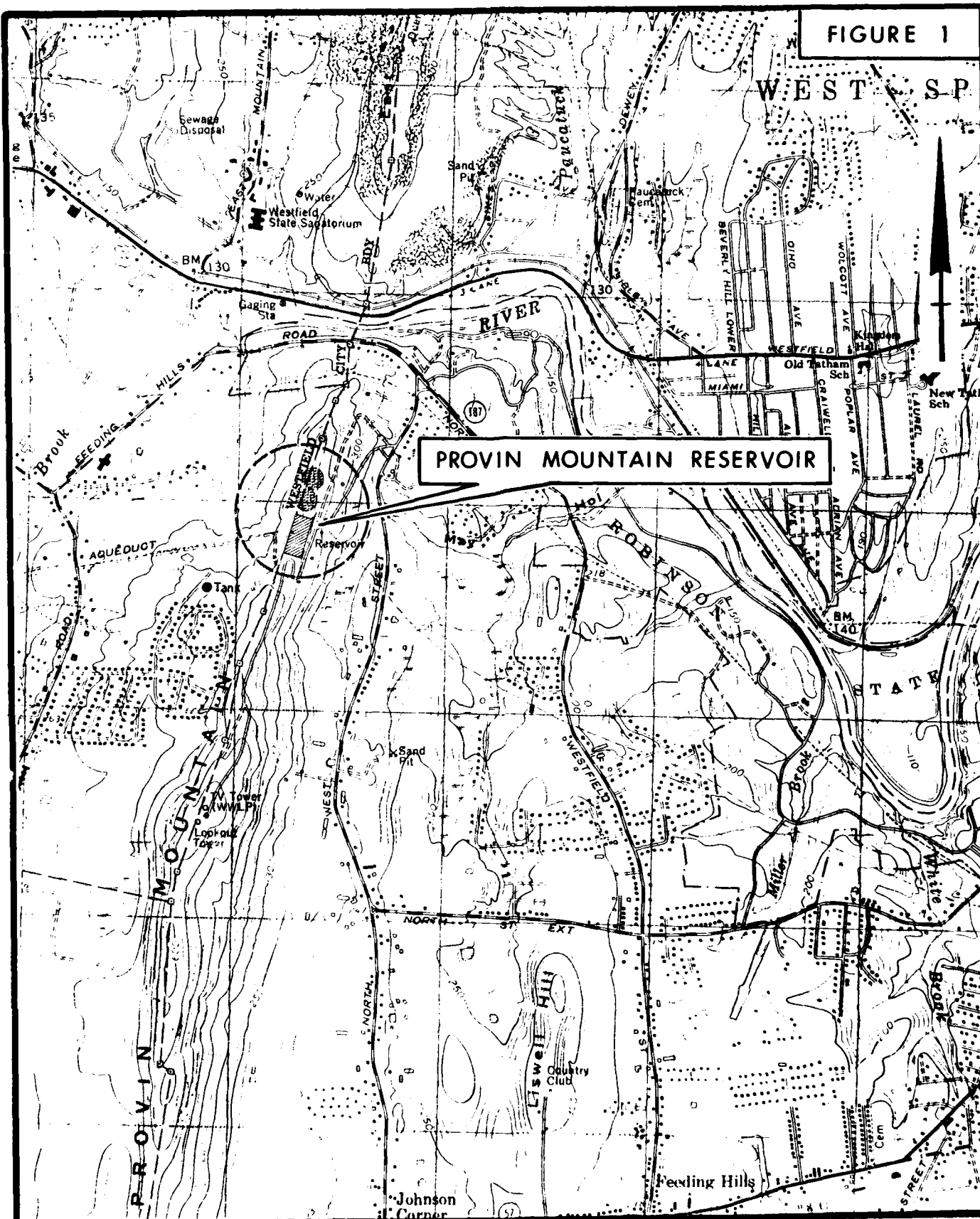
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NEW ENGLAND DIVISION
WALTHAM , MASSACHUSETTS

CULLINAN ENGINEERING CO.,INC.
CIVIL ENGINEERS
AUBURN-BOSTON , MASSACHUSETTS

NATIONAL PROGRAM
OF INSPECTION
OF NON - FED. DAMS

Provin Mountain Reservoir
City of Springfield Aqueduct
Agawam, MA
MA 00528
March 4, 1981

FIGURE 1



LOCATION MAP

PROVIN MOUNTAIN RESERVOIR
AGAWAM MASS

1" = 2083'

CULLINAN ENGINEERING CO., INC.

WEST SPRINGFIELD, MASS QUADRANGLE 1979

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

PROVIN MOUNTAIN RESERVOIR

SECTION 1

PROJECT INFORMATION

1.1 GENERAL

(a) Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Cullinan Engineering Co., Inc., has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Contract No. DACW 33-81-C-0025, dated December 19, 1980, has been assigned by the Corps of Engineers for this work.

(b) Purpose:

- (1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.
- (2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.
- (3) Update, verify and complete the National Inventory of Dams.

1.2 DESCRIPTION OF PROJECT

(a) Location. Provin Mountain Reservoir is located on top of Provin Mountain in the Town of Agawam, Hampden County, Massachusetts (see Location Map). The coordinates for the dam are 72 degrees 41.9 minutes longitude and 42 degrees 05.8 minutes latitude.

(b) Description of Dam and Appurtenances. Provin Mountain Reservoir consists of four reinforced concrete storage tanks, inlet and outlet gatehouses, a flow meter chamber, meter house, venturi chamber, and numerous valve chambers. The tops of the tanks are grass covered and the exposed slopes are 1:1 hand-placed stone at Reservoir No's 1 and 2, and end-dumped stone at Reservoir No's 3 and 4. All four tanks are vented by means of manhole covers set in concrete curbs cast through the roof sections (see Appendix B and Photos No's. 1 and 2).

The four concrete reservoirs were constructed in three separate phases. Phase one was the construction of a 288 foot by 320 foot rectangular concrete tank with a maximum depth of about 30 feet, referred to as Reservoir No. 1. A series of elliptical arches 16 feet on center supported by 2 foot square columns form the roof of this structure. The floor of the tank is a reinforced concrete slab having a minimum thickness of 4 inches. The walls of the tank vary in thickness from 18 inches to 38 inches depending on their height and lateral support conditions with the outside faces of the walls battered 1-inch in 24 inches. Both the inlet and outlet lines for Reservoir No. 1 are 42-inch diameter pipes. The tank is vented and has 2 feet of earth over the roof of the structure. Abutting the outside walls are 1:1 stone fill slopes.

The second phase of work occurred in 1932-33 and included the construction of Reservoir No. 2, another rectangular concrete tank. This structure is located adjacent to Reservoir No. 1 and is 288 feet by 224 feet in size. The construction design and composition of Reservoir No. 2 is substantially the same as described for Reservoir No. 1 with the following exceptions: the depth varies from 22 feet to 37.5 feet, some of the roof support columns are 26 inches square, the inlet pipe is 60 inch diameter, and the outlet pipe is 72-inch diameter reduced to a 66-inch diameter immediately outside the structure. Also, an aeration pipe network and concrete tank were included in the construction of Reservoir No. 2.

The third and final work phase included the erection of two 320 foot diameter circular reinforced concrete tanks with aerators. These structures are referred to as Reservoir No. 3 and Reservoir No. 4. These reservoirs are of similar design and construction, and are basically symmetrical about the aerator control house between them. The roof slabs are reinforced concrete 9 inches thick supported by 24-inch and 28-inch diameter reinforced concrete columns. There is approximately two feet of earth fill over the roof. The reinforced concrete side-walls are 18 inches thick, and the floor slabs are a minimum of 5 inches of reinforced concrete. These tanks average about 29.5 feet in depth. There is a bank of four 36-inch diameter equalizer pipes between Reservoir No's 2 and 3. The common intake well serves as an equalizer between Reservoir No's 3 and 4. The feed to the intake well is a 60-inch diameter pipe. The outlets for both circular tanks are 42-inch diameter pipes which connect to a common 60-inch outlet pipe. Aerators are positioned over each tank but are no longer used as part of the normal operating procedure.

Water is supplied to the reservoirs by three inlet aqueducts which flow into Inlet Chamber No. 1 (see Photos No's. 3 and 4). The inlet aqueducts are 42, 48 and 60 inches in diameter. The water is distributed to the tanks from this control structure. Reservoir No's 1 and 2 are fed by 42-inch and 60-inch supply lines, respectively, while reservoir No's 3 and 4 are fed by a single 60-inch supply line through a central intake well for both structures. Outflow from the tanks is controlled by separate valve chambers for each tank, and by a common gate chamber where the individual outlet pipes congregate in the meter house. Overflow capability for the facility is provided by three 30-inch diameter outlet pipes which discharge to a paved waterway on the westerly side of the site (see Photo No. 8).

(c) Size Classification. The maximum height of the concrete reservoir walls is 30 feet and the estimated storage capacity is 184 Acre-Feet. According to guidelines established by the Corps of Engineers, the dam is classified in the "small" category on both height and storage capacity.

(d) Hazard Classification. The results of the dam failure analysis indicate that the assumed failure outflow would travel eastward down the mountain as sheet flow, inundating and severely damaging the access road and two buildings before reaching a stream channel flowing northward. The failure outflow would then follow the stream channel, overtopping two roadways by 8 to 10 feet and inundating at least two buildings in a residential area with 5 to 10 feet of water before reaching the Westfield River where the peak would be attenuated. Prior to a failure there would be no water at the residential buildings and only normal stream flow through the culverts under the subject roadways. Consequently, with the potential loss of more than a few lives, the appreciable economic loss and the loss of a water supply that would occur, the dam has been classified in the "high" hazard category.

(e) Ownership. The four concrete reservoirs are owned by the City of Springfield, City Hall, Court Street, Springfield, Massachusetts.

(f) Operator. The reservoir facility is operated by Mr. William Sullivan, Superintendent of Provin Mountain Reservoir, and a full-time maintenance staff. Mr. Sullivan resides on the site and his address is Northwest Street, West Feeding Hills, Agawam, Massachusetts (telephone 413/786-3030).

(g) Purpose of the Dam. Provin Mountain Reservoir provides water storage and regulates its release as part of the water supply system for the City of Springfield, Massachusetts.

(h) Design and Construction History. Construction at the Provin Mountain site has taken place in three phases. Phase one included the construction of the first rectangular concrete tank. Plans for this phase were prepared by Elbert E. Lochridge, Chief Engineer;; Allen Hazen, Consulting Engineer; and L.G. Carlton, Resident Engineer. This structure was reportedly built in 1910. Plans for Phase two, the second rectangular tank and aerator, were prepared by Elbert E. Lochridge, Chief Engineer; Chester M. Everett, Consulting Engineer; and James B. Porter, Resident Engineer. The related construction took place in 1932-33. The final phase included the construction of the two circular concrete tanks in 1958. Plans for this work were prepared by Bogert and Childs, Consulting Engineers, New York, New York.

(i) Normal Operating Procedure. Maintenance on the dam is performed on a routine schedule by a full-time staff. The superintendent of Provin Mountain Reservoir resides on the site. The tank levels and outflow rates are reportedly checked three times a day by the staff at 8 AM, 4 PM and 8 PM. Inflow to the facility originates from Cobble Mountain Reservoir, located twenty miles to the west of the site in the Towns of Blanford and Granville. Between Cobble Mountain Reservoir and Provin Mountain Reservoir the water is processed through either slow sand filters or dual media rapid sand filters at the West Parish Filter Plant in Westfield. Before leaving the filtration plant, chlorine is added to the water. Inflow to Provin Mountain Reservoir is regulated at the West Parish Filter Plant.

1.3 PERTINENT DATA

(a) Drainage Area. Since Provin Mountain Reservoir sits on top of a mountain and consists of four holding tanks fed by a regulated aqueduct, the drainage area size and characteristics do not have a direct bearing on the inflow to the facility.

(b) Discharge at the Dam Site. Normally, the water is drawn off from the reservoirs by the various outlets which feed the outlet aqueducts. Outflow is controlled by the various valve chambers on line. The outlet aqueducts then carry the water to the City of Springfield water supply system. The average daily discharge is reported to be about 37.7 million gallons per day with a maximum daily use of 75.69 million gallons occurring on June 30, 1971. There are also three 30-inch overflow pipes for the facility (see Plans Appendix B and Photo Location Plan p. C-1). These outflow pipes function when the water level in the tanks reaches an elevation of 404.8. The overflow discharge channel is a paved waterway on the westerly side of the site.

The following is a list of pertinent values relative to discharge:

1. Outlet Works (Conduit) Size: (a) 42" outlet from Reservoir No. 1
(b) 66" outlet from Reservoir No. 2
(c) 42" outlet lines from Reservoir No's 3 and No. 4 which combine into a common 60" line (see Plans)

Invert Elevation: 380±

Discharge: Average daily discharge reported to be approximately 37.7 MGD

2. Maximum Known Flood at Dam Site: N/A
3. Ungated Spillway Capacity at Top of Dam: N/A
4. Ungated Spillway Capacity at Test Flood Elevation: N/A
5. Gated Spillway Capacity at Normal Pool Elevation: N/A
6. Gated Spillway Capacity at Test Flood Elevation: N/A
7. Total Spillway Capacity at Test Flood Elevation: N/A
8. Total Project Discharge at Top of Dam: N/A
9. Total Project Discharge at Test Flood Elevation: N/A

(c) Elevation - Feet Above Mean Sea Level

1. Streambed at Toe of Dam: 187
2. Bottom of Cutoff: N/A
3. Maximum Tailwater: N/A
4. Normal Pool: N/A
5. Full Flood Control Pool: N/A
6. Spillway Crest: N/A
7. Design Surcharge (Original Design): Unknown
8. Top of Dam: 216
9. Test Flood Surcharge: 216.1
10. Other: 12" Overflow at El 212.0

(d) Reservoir - Length in Feet

1. Normal Pool: 1980 feet
2. Flood Control Pool: N/A
3. Spillway Crest Pool: N/A
4. Top of Dam: 2300 feet
5. Test Flood Pool: 2350 feet

(e) Storage - Acre-Feet

1. Normal Pool: 92 acre-feet
2. Flood Control Pool: N/A
3. Spillway Crest Pool: N/A
4. Top of Dam: 140 acre-feet
5. Test Flood Pool: 142 acre-feet±

(f) Peservoir Surface - Acres

1. Norral Pool: N/A
2. Flood Control Pool: N/A
3. Spillway Crest: N/A
4. Test Flood Pool: N/A
5. Top of Dam: 6 Acres (top surface area of tanks)

(g) Dam

1. Type: Concrete tank walls, earthfill, stone paved slopes
(downstream)
2. Length: 3200 Feet (perimeter of tanks)
3. Height: 30 Feet
4. Top Width: N/A
5. Side Slopes: Vertical upstream (tank walls)
1:1 downstream
6. Zoning: N/A
7. Impervious Core: N/A
8. Cutoff: N/A
9. Crout Curtain: N/A
10. Other: N/A

(h) Diversion and Regulatory Tunnel None

(i) Spillway None

(j) Regulating Outlets

1. Invert: 180± (all)
2. Size: 42", 66", 2-42" combining to 60"
3. Description: Outlets into City of Springfield Water Supply
System from Peservoir No's. 1, 2, 3, and 4,
respectively
4. Control Mechanism: Manually operated valves (all lines)
5. Other: N/A

SECTION 2 ENGINEERING DATA

2.1 GENERAL

Construction at Provin Mountain has taken place in three separate phases. Record plans for all three phases were obtained from the City of Springfield Water Department. Phase one construction plans for the first rectangular concrete reservoir were prepared in 1910 by Elbert E. Lochridge, Chief Engineer; Allen Hazen, Consulting Engineer; and L.G. Carlton, Resident Engineer. Plans for phase two, the second rectangular concrete reservoir, were prepared in 1931-33 by Elbert E. Lochridge, Chief Engineer; Chester M. Everett, Consulting Engineer; and James B. Porter, Resident Engineer. The final phase included the construction of the two circular concrete tanks. Plans for this work were prepared in 1958 by Bogert and Childs, Consulting Engineers, New York, New York.

Periodic inspection reports and sketches by the Massachusetts DPW were obtained from the Division of Waterways.

2.2 CONSTRUCTION RECORDS

The above mentioned record plans are available from the City of Springfield Water Department for all three phases of construction.

2.3 OPERATIONAL RECORDS

Tank levels and outflow are metered continuously with the meters read by personnel of the Springfield Water Department three times a day (8:00 AM, 4:00 PM, 8:00 PM). Records of the tank levels and outflow are maintained by the Springfield Water Department.

2.4 EVALUATION

(a) Availability. Documents described in Section 2.1 above are available from the City of Springfield, Water Department, City Hall, Court Street, Springfield, Massachusetts and the Division of Waterways, State of Massachusetts.

(b) Adequacy. The available data, in combination with the visual evaluation described in the following section, is adequate for the purpose of the Phase I Investigation.

(c) Validity. The general observed configuration of the reservoirs and appurtenances were in good agreement with the record plans.

SECTION 3
VISUAL OBSERVATIONS

3.1 FINDINGS

(a) General. Provin Mountain Reservoir is a series of four enclosed reinforced concrete storage reservoirs with stone filled containment dikes constructed on the ridge of Provin Mountain. At the time of inspection all reservoirs were full, precluding access. Therefore, it is recommended that the tanks be dewatered and the interior of all the tanks be inspected by a qualified registered engineer. The visual inspection of the site was made on March 4, 1981. A copy of the inspection checklist is included in Appendix A. Provin Mountain Reservoir is in fair condition at the present time pending inspection of the tank interiors.

(b) Storage Tanks and Containment Dikes. Provin Mountain Reservoir is comprised of four underground reinforced concrete tanks identified as Reservoir No's 1, 2, 3 and 4. Reservoir No. 1 and Reservoir No. 2 are located at the southerly end of the site and are of rectangular configuration. Reservoir No's 3 and 4 are circular tanks located immediately to the north. All four tanks are vented by means of manhole covers set in concrete curbs (see Appendix B and Photos No's. 1 and 2). Rock fill containment dikes abut the exterior of the tanks along the entire length of the east and west walls and along portions of the north and south ends (see Photos No's. 7, 8, 9, and 11).

The rock slope along Reservoir No. 1 is hand-placed and is in good condition. There is a minor sloughed area on the lower southerly portion of the fill but it is of no structural significance. Other minor sloughed areas exist on the east and west sides of the containment dike near Reservoir No. 1. Although the hand-placed rock slopes are in generally good condition, there is evidence of minor creep, particularly on the westerly slope, with a tendency towards bulging in the lower half of the slope of not more than one foot from the original plane. However, these bulges do not appear to have any practical engineering significance and should merely be inspected periodically to see if any major changes occur.

The hand-placed rock slope along the east and west sides of Reservoir No. 2 is in excellent condition. There is an abrupt change in slope between the hand-placed section and the end dumped section between Reservoir No's 2 and 3. The slopes along Reservoir No's 3 and 4 are end-dumped rather than hand-placed.

The material in these dikes is screened trap rock ranging in size from approximately 3 inches to 12 inches. It is angular, blocky hard basaltic rock. The slopes are uniform and in excellent condition with no bulging or movement noted. There is a rock spoil area located to the west of Reservoir No. 4.

There is some clear and clean seepage accumulated along the toe of the east dike of Reservoir No. 2 in a low spot near a manhole (see Photo No. 12). The total flow is estimated to be 5 to 10 gpm. A small boil issuing about 1 gpm of clear, clean water is located northeast of Reservoir No. 2 near a catch basin. It is the opinion of Mr. William Sullivan, Superintendent of Provin Mountain Reservoir, that the seepage is coming from a spring in the bedrock beneath the reservoirs. It is understood from observations that the seepage occurs when Reservoir No's 1 and 2 are full and Reservoir No's 3 and 4 are empty, and when Reservoir No's 1 and 2 are empty and Reservoir No's 3 and 4 are full. Also, the same seepage appears when all the reservoirs are full. There are drains on the outside of the reservoirs which collect groundwater. However, the evidence indicates that the water is coming from springs through the cracks and seams of the underlying bedrock. Nevertheless, this seepage should be studied by an Engineer and monitored by the Owner until the recommendations of the engineering study have been implemented. There is no evidence of any seepage from Reservoir No's 1, 3 and 4.

(c) Appurtenant Structures

(1) West Gate House (Inlet Chamber No. 1)

This structure consists of concrete masonry unit walls with a concrete floor and tiled roof (see Photo No's 3 and 4). The structure is in good condition.

The building houses two hand-crank operated bench stands manufactured by the Chapman Valve Mfg. Co. The right gate, which controls the 60-inch intake was open 48 inches at the time of inspection. The left gate, which controls the 42-inch intake was fully closed. The bench stands and stems are well maintained and in good operating condition.

(2) North Gate House (Inlet Chambers 3 and 4)

This structure consists of a reinforced concrete frame and roof with cement concrete masonry unit non-bearing walls. The floor consists of metal grating and the sub-floor is concrete (see Photos No's. 5 and 6). The structure is in good condition.

The building houses two hand crank operated bench stands manufactured by the Chapman Valve Mfg. Co. Both gates were opened by approximately 48-inches. The bench stands and stems are well maintained and in good operating condition.

The structure also houses eight additional gates and a compressor for operation of the aeration system. This system appears to be in good condition.

(3) East Gate House (Outlet Chambers 1, 2, 3 and 4

This structure houses two hand crank operated bench stands. Both gate valves were in the open position at the time of inspection.

- (d) Reservoir Area. The reservoir is located on the ridge of Provin Mountain and consists of four enclosed concrete tanks. The tanks are grass covered on the top and have stone riprap embankments on the sides. There are several control and maintenance structures located on the site. Aerators are located on top of three of the tanks.
- (e) Downstream Channel. Normal discharge from the Provin Mountain facility is through aqueducts to the City of Springfield water supply system. However, in the event of the assumed failure, the discharge outflow would travel as sheet flow down the mountain across the access road to a natural stream channel. The channel flows in a northerly direction under two roads before reaching the Westfield River, approximately 6400 feet downstream of the reservoir.

3.2 EVALUATION

The visual inspection indicates that Provin Mountain Reservoir is in fair condition pending inspection of the tank interiors. There are some minor deficiencies pertaining to localized slumps in the rock slopes of the containment dikes on the east and west side of Reservoir No. 1, and some seepage emanating from the ground northeast of Reservoir No. 2. Measures to improve these conditions are stated in Section 7.3.

SECTION 4
OPERATING AND MAINTENANCE PROCEDURES

4.1 OPERATING PROCEDURES

(a) General. A standard daily operating procedure is followed at Provin Mountain Reservoir. Generally, water levels in the tanks are taken at 8:00 AM. An estimate is then made of the amount of filtered water that will be needed to sustain the appropriate level in the tanks. Raw water is then processed at the West Parish Filter Plant and the inflow to Provin Mountain Reservoir is controlled at the plant.

(b) Warning System. There is a warning system at the reservoir that notifies the operator as to high and low water levels in the four tanks. Should a high or low level condition occur in the tanks, an alarm system notifies the operators of the condition. The filter plant is then informed to increase or decrease the amount of water being supplied to this holding tank installation. There is no established emergency preparedness plan in effect for this structure.

4.2 MAINTENANCE PROCEDURES

(a) General. Maintenance to the exterior portion of the reservoir facility is on a regular and continuous basis. The interior of the tanks have not been checked for several years and have never been inspected by a Registered Engineer. It is recommended that an inspection of the interior of the tanks be included as part of the program of yearly technical inspections.

(b) Operating Facilities. Regulating valves and controls are operated continuously by the maintenance personnel at the site. All controls are reported to be in good working order.

4.3 EVALUATION

The reservoir and operating facilities are generally maintained in excellent condition. Formal operational procedures, maintenance programs and a warning system are in effect for Provin Mountain Reservoir. However, a formal "Emergency Action Plan" should be developed to include an effective preplanned downstream warning system, locations of emergency equipment, materials and manpower, authorities to contact and potential areas that require evacuation. In addition, the Owner should implement a program of annual technical inspections, including inspection of the interior of the tanks, by a Qualified Registered Engineer.

SECTION 5
EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

- 5.1 General. Provin Mountain Reservoir consists of four concrete holding tanks constructed on the ridge of a mountain. The reservoir is fed by three aqueducts (42, 48, and 60 inches in diameter) from a supply reservoir at Cobble Mountain Dam, located about 20 miles west of the City of Springfield, Massachusetts. The combined capacity of the four reservoir structures is about 60 million gallons (184 acre-feet). All four reservoirs have an average depth of about 30 feet. Normal discharge is through the three outlet aqueducts (42, 48, and 60 inches in diameter). Three 30-inch outlet pipes are used for overflow from the reservoirs. The facility is also equipped with an alarm system for detecting high and low water conditions in the tanks.
- 5.2 Design Data. Design and record plans for the reservoir were obtained from the City of Springfield, Water Department. No computations for the reservoir were available.
- 5.3 Experience Data. Tank levels and outflow are metered continuously and the meters are read three times a day at 8:00 AM, 4:00 PM, and 8:00 PM by the full-time staff. The inflow to the site is normally regulated at the filtration plant. The average daily flow through the reservoir is reported to be about 37.7 million gallons with a maximum daily output of 75.69 million gallons on June 30, 1971.
- 5.4 Test Flood Analysis. Since Provin Mountain Reservoir consists of four enclosed tanks on top of a mountain ridge that are supplied by regulated aqueducts, development of a test flood was not warranted.
- 5.5 Dam Failure Analysis. For the purposes of this study, it was assumed that all four tanks were full to capacity at the time of failure. To determine the peak failure outflow, a failure was assumed along 40% of the width of the east wall of both rectangular tanks. The resultant outflow would be 66,300 cfs. The total capacity of all tanks is 60,000,000 gallons.

As a result of the failure of the tanks, water supply to the City of Springfield would be disrupted. Failure outflow from the ruptured tanks would travel eastward down the mountain as sheet flow, inundating and causing severe damage to the access road and two buildings before reaching a stream channel flowing in a northerly direction. Flow in this channel prior to the dam failure would consist of nor-

mal streamflow only, with no overtopping of roads or damage to residential properties. The failure outflow would then travel downstream overtopping North West Street by 8 to 9 feet with damage occurring to at least two buildings in a residential area. From examination of the U.S.G.S. sheets, it is anticipated that flow at these residential structures would be 5 to 10 feet deep. The outflow would continue downstream reaching another roadway 5100 feet from the reservoir. At this point North Westfield Street would be overtopped by about ten (10) feet. Approximately 1300 feet downstream of this section, the flow reaches the Westfield River where the peak would be attenuated. Consequently, with a sizeable economic loss, a potential loss of more than a few lives, and the loss of water supply, the overall potential hazard from a dam failure at Provin Mountain Reservoir would be "high".

SECTION 6 STRUCTURAL STABILITY

6.1 VISUAL OBSERVATIONS

The visual inspection of the Provin Mountain Reservoir indicates that the structures are in fair condition pending inspection of the tank interiors. There were no significant displacements or distress which would warrant structural stability calculations. However, there were a few items of a maintenance nature and items requiring monitoring and analytical studies that should be performed to assess the factor of safety of the reservoir under earthquake and present loading conditions. Monthly inspections should be made to monitor any changes in the seepage noted at the northeast corner of Reservoir No. 2 until the recommendations of the engineering study have been implemented.

6.2 DESIGN AND CONSTRUCTION DATA

Definitive plans of the four underground reservoirs and the stone filled containment dikes were reviewed. Structural evaluations indicate that with the reservoir full the reinforced concrete must rely on some resistance from the stone dikes to provide proper stability. Should the stone embankments be removed from either the east or west walls of Reservoir No's 1 and 2, these structures would become unstable. Calculations pertaining to the design of these vertical walls are not available. Since the exterior rock filled slopes are one horizontal to one vertical, they may be of marginal stability under earthquake loading conditions.

6.3 POST-CONSTRUCTION CHANGES

Selected design drawings are contained in the appendix. There is no evidence of post-construction changes which would alter the stability or safety of the reservoirs.

6.4 SEISMIC STABILITY

The project is located in Seismic Zone No. 2, and in accordance with recommended Phase I Guidelines, does not warrant seismic analysis. However, because of the design of the concrete wall in Reservoir No.'s 1 and 2, stability may rely on passive earth pressures from the rock slopes containing these walls. Because the slopes may be unstable under earthquake loading, analytical studies may be required as outlined in Section 7.

SECTION 7
ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 PROJECT ASSESSMENT

(a) Condition. The Provin Mountain Reservoir is in fair condition at the present time pending further inspection of tank interiors. Items of concern included minor seepage at the toe of rock slope northeast of Reservoir No. 2, and minor localized sloughing of the hand-placed rock slope on the east, south and west of Reservoir No. 1. Because of the relatively steep rock filled slopes they may become unstable during earthquake loading. Since the design of the vertical walls on the east and west sides of Reservoir No.'s 1 and 2 rely partly on passive resistance from these filled slopes, calculations should be made as to the safety factor under earthquake loading, present loading conditions and full reservoir conditions.

(b) Adequacy of Information. Design drawings are available for the four reservoirs and appurtenant structures. Consequently, the adequacy of the engineering data is considered good. The assessment of this project is based on a review of these drawings plus the visual inspection conducted on March 4, 1981.

(c) Urgency. The recommendations and remedial measures enumerated below should be implemented by the owner within one year of receipt of this Phase I inspection report.

7.2 RECOMMENDATIONS

It is recommended that the Owner engage a Registered Professional Engineer to:

(a) Inspect the interior walls and floor slab of all tanks.

(b) Undertake an analytical study of the stability of Reservoir No.'s 1 and 2 under earthquake loading and present loading conditions.

The Owner should implement the recommendations of the above engineering studies.

7.3 REMEDIAL MEASURES

(a) Operation and Maintenance Procedures

- (1) Reshape localized slumps in hand-placed rock filled slopes on east, west and south sides of Reservoir No. 1.

- (2) The Owner should inspect the interior of all tanks on a regular basis.
- (3) Implement a program of yearly technical inspections by a qualified registered engineer with particular emphasis on the seepage emanating from the ground to the northeast of Reservoir No. 2. Pay particular attention to any change in the quantity or clarity of the seepage. Also, the inspection should include the interior examination of the concrete reservoirs when they are empty.
- (4) Monitor seepage on a monthly basis until the recommendations of the engineering study have been implemented.
- (5) Monitor bulge on westerly rock slope of Reservoir No. 1 and pay specific attention to any major changes that may occur.
- (6) Develop an "emergency action plan" that will include an effective preplanned downstream warning system, locations of emergency equipment, materials and manpower, authorities to contact, and potential areas that may require evacuation.

7.4 ALTERNATIVES

There are no practical alternatives to the above recommendations and remedial measures.

APPENDIX A
INSPECTION CHECKLISTS

INSPECTION TEAM ORGANIZATION

Date: March 4, 1981

Project: MA 00528
Provin Mountain Reservoir
Agawam, Massachusetts

Weather: Clear, cold

INSPECTION TEAM

William S. Parker	Cullinan Engineering Co., Inc. (CEC)	Team Captain
Kenneth W. Hodgson, Jr.	CEC	Hydraulics
Gregory M. Valiton	CEC	Hydraulics
Williar S. Zoino	Goldberg, Zoino & Associates (GZ)	Soils
Steven J. Trettel	GZ	Soils
Andrew Christo	Andrew Christo Engineers, Inc (ACE)	Structures
Paul Razgha	ACE	Structures
Carl Razgha	ACE	Structures

March 4, 1981

CHECKLISTS FOR VISUAL INSPECTION

<u>AREA EVALUATED</u>	<u>BY</u>	<u>CONDITION & REMARKS</u>
<u>CREST OF SLOPES AND TOP OF RESERVOIRS</u>		
Vegetation	CZ	None
Sloughing or Erosion		None
Surface Cracks		None
Movement or Settlement		Minor settlement (6"+) of rock backfill around Reservoir No. 4
<u>DOWNSTREAM SLOPE OF ROCK CONTAINMENT DIKES</u>		
Vegetation		None
Sloughing or Erosion		Minor sporadic sloughing of slopes
Surface Cracks		None
Animal Burrows		None
Movement or Cracking Near Toe		None
Unusual Embankment or Downstream Seepage		Minor seepage east of intersection of tanks 2 and 3 believed to be rock springs and estimated at 1-2 gpm.
Piping or Boils		See previous item
Foundation Drainage Features		Inaccessible
<u>GENERAL</u>		
Lateral Movement		Minor localized bulges in slopes
Vertical Alignment		Good
Horizontal Alignment		Good
Condition at Abutments and at Structures	GZ	Good

PROVIN MOUNTAIN RESERVOIR
MA 00528

March 4, 1981

CHECKLISTS FOR VISUAL INSPECTION

<u>AREA EVALUATED</u>	<u>BY</u>	<u>CONDITION & REMARKS</u>
Indications of Movement of Structural Items	GZ	None
Trespassing		None
Instrumentation Systems		None
<u>WEST GATE HOUSE</u>		
Structure		Good
Gate Bench Stands		Good
<u>NORTH GATE HOUSE</u>		
Structure		Good
Gate Bench Stands		Good
<u>EAST GATE HOUSE</u>		
Structure		Good
Gate Bench Stands	ACE	Good

APPENDIX B
ENGINEERING DATA

MUNICIPAL WATER WORKS
SPRINGFIELD, MASSACHUSETTS

Early History Before Little River Watershed

The City of Springfield purchased the then existing water works consisting of small surface supplies within the city limits in 1872, from the Springfield Aqueduct Company for approximately \$250,000.

In 1871 water was turned into the mains from the Ludlow Reservoir Supply and this supply served the city until 1910. Since 1910, the Little River Supply, with its large impounding reservoir at Cobble Mountain has constituted the chief source; augmented by the Ludlow Supply. These sources have a combined dependable yield of approximately 65 million gallons per day.

Description of System

Springfield's "Little River Supply" has natural advantages which make it a superior water supply from the start. The source of supply is located about twenty miles west of the city up in the hilltowns of Blandford and Granville where habitations are scarce and the possibility of contamination is slight.

The area from which water drains into our man-made reservoirs is called the watershed and comprises 48.5 square miles of hills and valleys containing innumerable springs and mountain streams. Cobble Mountain Dam was built just below the junction of two of the larger streams, Borden Brook and Pebble Brook, and forms Cobble Mountain Reservoir, which extends west from the dam some five miles and has a water surface area of 1,134 acres when full.

The city purchased all the land at the site of the reservoir and well back from the shores. In all, the city owns some 12,000 acres of land within this watershed area.

The Littleville Flood Control and Water Supply Dam and Reservoir was built on the Middle Branch of the Westfield River in October 1965 by the U.S.

Corps of Engineers at a cost of \$7,260,798.05. The City of Springfield has the water rights in the reservoir between the elevations of 432' and 518' and will pay the U. S. Government a sum of \$2,202,160.48 over a period of thirty years.

The dam contains 32,400 acre feet (10,600 m.g.) of water at spillway level and the City of Springfield's water supply pool contains 9,400 acre feet (3,080 m.g.) of water. This pool has a safe yield of 20 million gallons per day. The watershed area of Littleville is 52.3 square miles.

The water flows by gravity from the dam to the Huntington Pumping Station through a 48" supply line and is then pumped over the mountain to a terminal structure north of Cobble Mountain Reservoir through a 48" discharge pipeline, where it is discharged into a channel that flows into Cobble Mountain Reservoir from where it goes into the rest of our system.

To safeguard the water at its source, the Massachusetts Department of Public Health has set up rules forbidding boating, bathing or fishing in these waters. Then as a further safeguard, all the water coming to the city is filtered at the West Parish Filter Plant located in the West Parish of Westfield. There, we have 10 covered slow sand filters with a total filtering area of 6.82 acres where the water passes down through 42" of clean sand and about 12" of gravel. This process removes dirt, organic matter and harmful bacteria from the water. Periodically the filter sand is removed to sand washing machines, cleaned and replaced so that we use this same special sand over and over again. This process is called slow sand filtration. Chlorine is also added to the water at the filters as it leaves the plant.

There is also a Dual-Media Rapid Sand Filter plant in operation which can handle 10 million gallons per day. This plant along with the slow sand filters gives us a capacity of 100 million gallons per day at present and as

the need arises we can expand the rapid dual-media plant.

The filtered water passes through large size steel and concrete pipes from the filters to the concrete distributing reservoir on Provin Mountain, located near the Agawam-Westfield townline. From there it reaches the city through similar large size carrying mains and then through smaller mains and service pipes to the user.

Ludlow Reservoir now supplies only the Town of Ludlow.

System as of 1975

The present water system of the City of Springfield comprises the three sources of supply; two filter plants; distributing reservoir at Provin Mountain and about 585 miles of mains; serves nearly a quarter of a million people and numerous industries. There were about 40,000 service connections as of December 31, 1974. The use in 1965 was 13,496,704,700 gallons or 36.97 million gallons a day. In 1974, the amount used was 13,769,844,000 gallons or 37.7 million gallons a day. The maximum daily use was 75.69 million gallons on Wednesday, June 30, 1971.

INSPECTION REPORT - DAMS AND RESERVOIRS

1. LOCATION:

City/Town Agawam County Hampden Dam No. 2-7-5-10

Name of Dam Provin Mountain Reservoir

Topo Sheet No. 123 Mass. Rect. Coordinates: N 402,000, E 274,500

Inspected by: Harold T. Shumway Date July 7, 1976 Last Inspection 5-1-74

2. OWNER/S: As of July 7, 1976

per: Assessors X, Reg. of Deeds , Prev. Insp. X, Per. Contact y

1. City of Springfield, City Hall, Court St., Springfield, Mass.
Name St. & No. City/Town State Tel. No.

2.
Name St. & No. City/Town State Tel. No.

3.
Name St. & No. City/Town State Tel. No.

CARETAKER: (if any) e.g. superintendent, plant manager, appointed by
absentee owner, appointed by multi owners.
Mr. William Sullivan
Supt. of Provin Mt. Reservoir, Northwest St., West Feeding Hills, Mass. 786-3030
Name St. & No. City/Town State Tel. No.

3. DATA:

No. of Pictures Taken None Sketches See description of Dam.
Plans, Where At Springfield Water Dept. Offices, City Hall, Springfield, Mass.

5. DEGREE OF HAZARD: (if dam should fail completely)*

1. Minor 3. Severe
2. Moderate X 4. Disastrous

Comments: Development around and on Provin Mountain expanding. Hazard could become severe depending on area of failure.

*This rating may change as land use changes (future development).

OUTLETS: OUTLET CONTROLS AND DRAWDOWN

No. 1 Location and Type: Aqueducts to Springfield Water Department's distributing systems.

Controls Yes, TFFD: Number of valves and gates provide different configuration of flow through reservoirs.

Automatic , Manual X, Operative Yes X, No .

Flow in and out of tanks controlled at all times by full time

Comments: Staff - aerators no longer used by dept.

No. 2 Location and Type: Overflows on each individual tank

Controls , Type:

Automatic X, Manual , Operative Yes X, No .

Comments: At elev. 404.5 water overflows into drain system

No. 3 Location and Type:

Controls , Type:

Automatic , Manual , Operative Yes , No .

Comments:

Drawdown present Yes X, No , Operative Yes X, No .

Comments: By use of various valves individual tanks can be emptied for servicing.

7. DAM UPSTREAM FACE: Slope Vertical, Top of Water at Dam 28'+

Conc.

Material: Turf , Brush & Trees , Rock fill , Masonry X, Wood .

Other

Conditions: 1. Good , 3. Major Repairs .

2. Minor Repairs X, 4. Urgent Repairs .

Comments: Minor surface cracks in concrete facing of two of the tanks per reservoir supt. - unable to verify on field inspection due to water level in tanks.

8. DAM DOWNSTREAM FACE: Slope 1 1/2:1

Material: Turf , Brush & Trees , Rock Fill X, Masonry , Wood .

Other Stone paving - hand placed - rock fill dumped and graded

Conditions: 1. Good , 3. Major Repairs .

2. Minor Repairs X, 4. Urgent Repairs .

Comments: a small area of stone paved slope shows disturbance of stones - has existed for some years and appears stabilized. Could have been caused by extreme frost action years ago.

9. EMERGENCY SPILLWAY: Available Yes. Needed .

Height Above Normal Water: 2' Ft.

Width Ft. Height Ft. Material 30" dia. overflow pipes.

Condition: 1. Good . 3. Major Repairs .
2. Minor Repairs . 4. Urgent Repairs .

Comments: Water inflow and outflow is controlled by valves, etc. Overflow
handled through 3 each 30" dia. pipes. Automatic alarm system goes off
when water level reaches elev. 404.0, or 0.5 below overflow inverts.

10. WATER LEVEL AT TIME OF INSPECTION: 25' Ft. Above X. Below .

Top Dam F.D. Principal Spillway .

Other Bottom of tanks

Normal Flooded 2' variable Ft.

11. SUMMARY OF DEFECTS/WORKS NOTED:

Growth (Trees and Shrubs) on Embankment	<u>None found</u>
Animal Burrows and Wadeways	<u>None found</u>
Damages to Slopes or Top of Dam	<u>See item #8 - comments</u>
Cracked or Damaged Masonry	<u>None observed</u>
Evidence of Seepage	<u>None found</u>
Evidence of Piping	<u>None found</u>
Leaks	<u>None found</u>
Erosion	<u>None found</u>
Trash and/or Debris Impeding Flow	<u>None found</u>
Clogged or Blocked Spillway	<u>None found</u>
Other	<u> </u>

12.

OVERALL CONDITION:

1. Safe X
2. Minor repairs needed _____
3. Conditionally safe - major repairs needed _____
4. Unsafe _____
5. Reservoir impoundment no longer exists (explain)
Recommend removal from inspection list _____

13.

REMARKS AND RECOMMENDATIONS: (Fully Explain)

Mr. William Sullivan, Supt. of Provan Mt. Reservoir, and Mr. F. Brodrick, Supervising Engr., Springfield Water Dept., were present during this inspection.

This installation consists of 4 concrete reservoirs 2 ea. rectangular, and 2 ea. circular tanks with a total capacity of approx. 60 million gallons, and covered with earth with stone paving on the side slopes. The aerators mentioned in previous reports are no longer used per Mr. Sullivan.

The entire installation appears to be well maintained by a fulltime crew. The turf cover on the top of installation is in excellent condition and mowed over. All of the stone paved slopes were of good grade and alignment with exception of a small area on the southeast slope. Here the paved slope has a disrupted area on the surface of a few feet in width and extending from the top of slope to approx. one half way down the slope. This disturbed area is a few inches in depth and has apparently existed for some years per Mr. Sullivan and from previous inspection reports. The displacement of the paving stones is assumed to have been caused by extreme frost or ice action of some years past and is now stabilized. This condition appears to be of an aesthetic nature and does not appear to pose any hazard to safety of the installation. Due to level of water surface in the concrete tanks it was not possible to inspect the interior surfaces. Mr. Sullivan stated there were minor surface cracks evident in some areas on the interiors of the tanks but that these cracks were not a serious problem at present time. There was no evidence of any seepage or leaks anywhere around the outside surfaces of the installation and structures appear to be in a satisfactory condition.

HTB/js

DISCUSSION: WHAT WE LEARNED AND RECOMMENDATIONS

200-5501

City/Town NEENAH . County Hampden . Dan No. 2-7-5-10 .

Name of Dam Provin Mountain Reservoir

Top Sheet No. 120. Mass. Sect. Coordinates: N 402,000, E 274,500

Inspected by: E. C. Galls, F.B.I., On May 1, 1974. Date
Last Inspection New Mexico

CITEA/S: as of December 1941

Per: Assessors , Per. of Seeds , Prev. Insp. , Per. Contact .

Name	St. & No.	City/Town	State	Tel. No.
1. City of Springfield, City Hall, Court St., Springfield, Mass.	736-2711			

Name	Seat No.	City/Town	State	Tel. No.
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No.	Name	City/Town	State	Tel. No.
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NOTE: The term, e.g., superintendent, plant manager, appointed by absentee owner, appointed by multiple owners.

William Sullivan, Northwest St., West Feeding Hills, Mass. 786-3530				
Name	Dist.	From Mt.	St. & No.	Tel. No.
			City/Town	State

2000

No. of Pictures Taken None. Sketches See description of Dam.
 Place, Where At Springfield Water Dept. Offices, City Hall,
Springfield, Mass.

NEVER OF FEAR. (If you should fail completely)*

1. Minor _____ 3. Severe _____

2. Moderate 3. . 4. Disastrous

Comments: Amount of damage in event of complete failure would vary from slight to severe depending on area of failure. Development around and on Proven Mountain is increasing so degree of hazard is changing.

* This rating may change as land use changes (future development).

⑥

OUTLETS: OUTLET CONTROLS AND DRAIN-DOWN

No. 1 Location and Type: Aqueducts to Springfield Water Department's distributing systems.Controls Yes, TYPE: Number of valves and gates provide different configuration of flow through reservoirs and aerators.Automatic X. Manual X. Operative Yes X, No .Comments: Full time staff plus residential operator control flow at all times.No. 2 Location and Type: Overflows on each individual tank.Controls , Type: .Automatic X. Manual . Operative Yes , No .Comments: .No. 3 Location and Type: .Controls , Type: .Automatic . Manual . Operative Yes , No .Comments: .Drawdown present Yes X, No . Operative Yes , No .Comments: By use of various valves individual tanks can be emptied for servicing.

⑦

DAM UPSTREAM FACE: Slope Vertical, Depth Water at Dam 12 1/2' ±.Material: Turf . Brush & Trees . Rock fill . Masonry . Wood .Other .Condition: 1. Good X. 3. Major Repairs .2. Minor Repairs . 4. Urgent Repairs .Comments: Visual inspection not performed; assumed from level of maintenanceand condition of valve chambers actually inspected

⑧

DAM DOWNSTREAM FACE: Slope 10:1.Material: Turf . Brush & Trees . Rock Fill X. Masonry . Wood .Other stone paving.Condition: 1. Good . 3. Major Repairs .2. Minor Repairs X. 4. Urgent Repairs .Comments: some winter frost movement of stone slope paving.to be repaired during summer.

9. EMERGENCY SPILLWAY: Available Yes. Needed .

Height Above Normal Water Zero Ft.

Width Ft. Height Ft. Material 30" overflow pipe.

Condition: 1. Good X. 3. Major Repairs .

2. Minor Repairs . 4. Urgent Repairs .

Comments: Water inflow and outflow can be controlled by valves, etc.

10. WATER LEVEL AT TIME OF INSPECTION: 12 Ft. Above . Below .

Top Dam F.L. Principal Spillway .

Other Bottom of tanks.

Normal Freeboard Varies Ft.

11. SUMMARY OF DEFICIENCIES NOTED:

Growth (Trees and Brush) on Embankment None.

Animal Burrows and Washouts None.

Damage to Slopes or Top of Dam Small amount frost movement of stone paving on slope. See Item #8.

Cracked or Damaged Masonry None observed.

Evidence of Seepage None observed.

Evidence of Piping None observed.

Leaks None observed.

Erosion None.

Trash and/or Debris Impeding Flow None.

Clogged or Blocked Spillway .

Other .

- 4 -

12.

OVERALL CONDITION:

1. Safe X
2. Minor repairs needed _____
3. Conditionally safe - major repairs needed _____
4. Unsafe _____
5. Reservoir impoundment no longer exists (explain)
Recommend removal from inspection list _____

13.

REMARKS AND RECOMMENDATIONS: (Fully Explain)

This installation of the Springfield Water Department is located on Provin Mountain near elevation 400 M.S.L. It is an equalizing reservoir where water treated at the West Parish filter is aerated and stored before entering the aqueducts to the Springfield Water Department distributing system. It consists of four separate covered reservoirs built on and into the top of a ridge. The entire installation was well maintained with a full time crew of six men, two of which occupy residences adjacent to the reservoirs.

The reservoirs are of concrete construction covered with earth and with a stone paving on the side slopes. Aerators are located on the tops of the reservoirs.

At the time of the inspection, Mr. Sullivan, Superintendent of Provin Mountain Reservoir, was not present, but another employee of the Water Department showed me through the gate houses and the inlet chamber located below Reservoirs 1 and 2. We also walked along the toe of the earth backing for the reservoirs' walls and checked surrounding area for seepage. Actual entry to the reservoir was not practical at that time. Because of the generally good condition of those portions of the installation viewed and apparent high level of maintenance, it is assumed that the condition of the interior would be satisfactory.

RCS/ja/vk

DESCRIPTION OF DAM

DISTRICT 2.

Submitted by A. C. Salls, P.E. Dam No. 2-7-5-10

Date May 1, 1957 City/Town AGAWAM

Name of Dam Provin Mountain Reservoir

1. Location: Topo Sheet No. 22 C Mass. Reet. Coordinates N 42,000 E 27,500

Provide 8 1/2" x 11" in clear copy of topo map with location of Dam clearly indicated.

In Provin Mountain at Agawam-Westfield line reached via private road
westerly off of West Street. Approximately 1200 ft. south of North Street.

2. Year built Around 1910 Reservoirs #3 & #4
Year/s of subsequent repairs added around 1955-56

3. Purpose of Dam: Water Supply ✓ Recreational _____
Flood Control _____ Irrigation _____ Other _____
Holding and distributing reservoirs

4. Drainage Area: 17/4 sq. mi. _____ acres.
Type: City, Bus. & Ind. _____ Dense Res. _____ Suburban _____ Rural, Farm _____
Wood & Scrub Land _____ Slope: Steep _____ Med. _____ Slight _____
Water supply to reservoirs by aqueduct from West Parish filters.

5. Normal Ponding Area: See notes Acres; Ave. Depth _____
Impoundment: * 60 million gals.; _____ acre ft.
Silted in: Yes _____ No ✓ Approx. Amount Storage Area _____
* Each reservoir holds 15 million gallons.

6. No. and type of dwellings located adjacent to pond or reservoir 1 residences
i.e. summer homes etc. _____ for generating personnel.

7. See attached
Dimensions of Dam: Length sketch Max. Height _____
Freeboard Varies
Slopes: Upstream Face Vertical concrete
Downstream Face 1 1/2 to 1. Stone paved
Width across top Varies - closed tanks - say 10' from inside

Dam No. 2-7-5-11

8. Classification of Dam by Material:

Earth Backing Conc. Masonry Tanks Stone Masonry _____
 Timber _____ Rockfill In slopes Other _____

8a. Dam Type: Gravity _____ Straight _____ Curved, Arched _____ Other Concrete walls backed with fill
 Overflow _____ Non-overflow X

9. A. Description of present land usage downstream of dam:

70 % rural; 30 % ~~urban~~ residential development

B. Is there a storage area or flood plain downstream of dam which could accommodate the impoundment in the event of a complete dam failure? Yes X No _____

C. Character Downstream Valley: Narrow _____ Wide X Developed 30%
 Rural 70% Urban _____

10. Risk to life and property in event of complete failure.

No. of people 7

No. of homes 5

No. of businesses Yes - access road to Channel 22 TV

No. of industries None Type _____

No. of utilities 3 Type _____

Railroads None

Springfield Water Supply - Possible damage to Westfield Water Supply - Brown Mt. distribution stand pipe. Electrical, telephone and gas distribution lines.

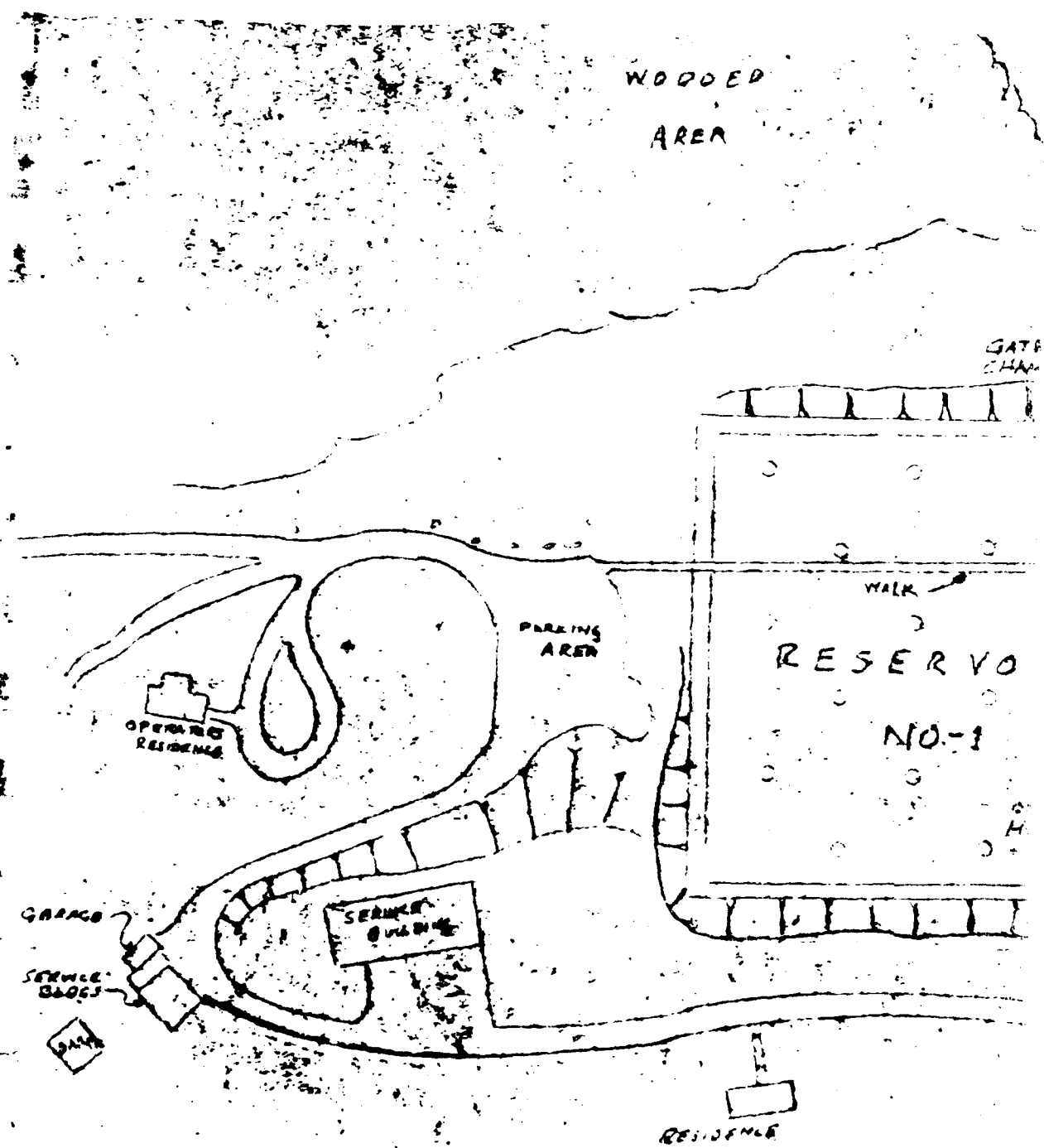
Other dams None immediately below

Other _____

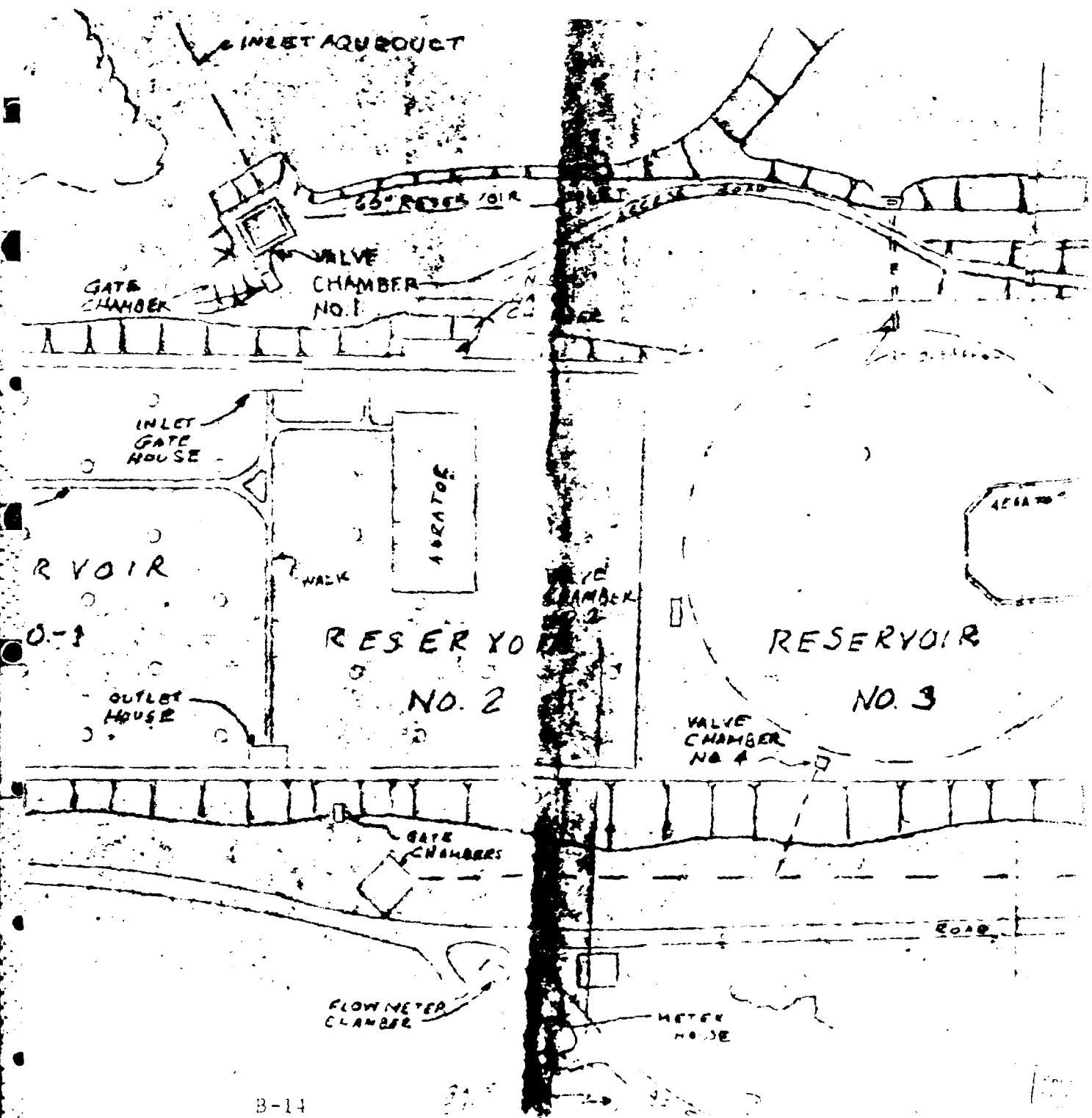
11. Attach sketch of dam to this form showing section and plan on 8 1/2" x 11" sheet.

POB:vk
 Attachments
 Local Plan
 Sketches

There are 4 reservoir tanks, each holding 15 million gallons. Reservoirs 1 and 2 built around 1910 are rectangular underground tanks each about 200 ft. square and 12 ft. deep. Reservoirs 3 and 4 built around 1985 are circular underground tanks - 320 ft. in diameter, 12.5 ft. deep.

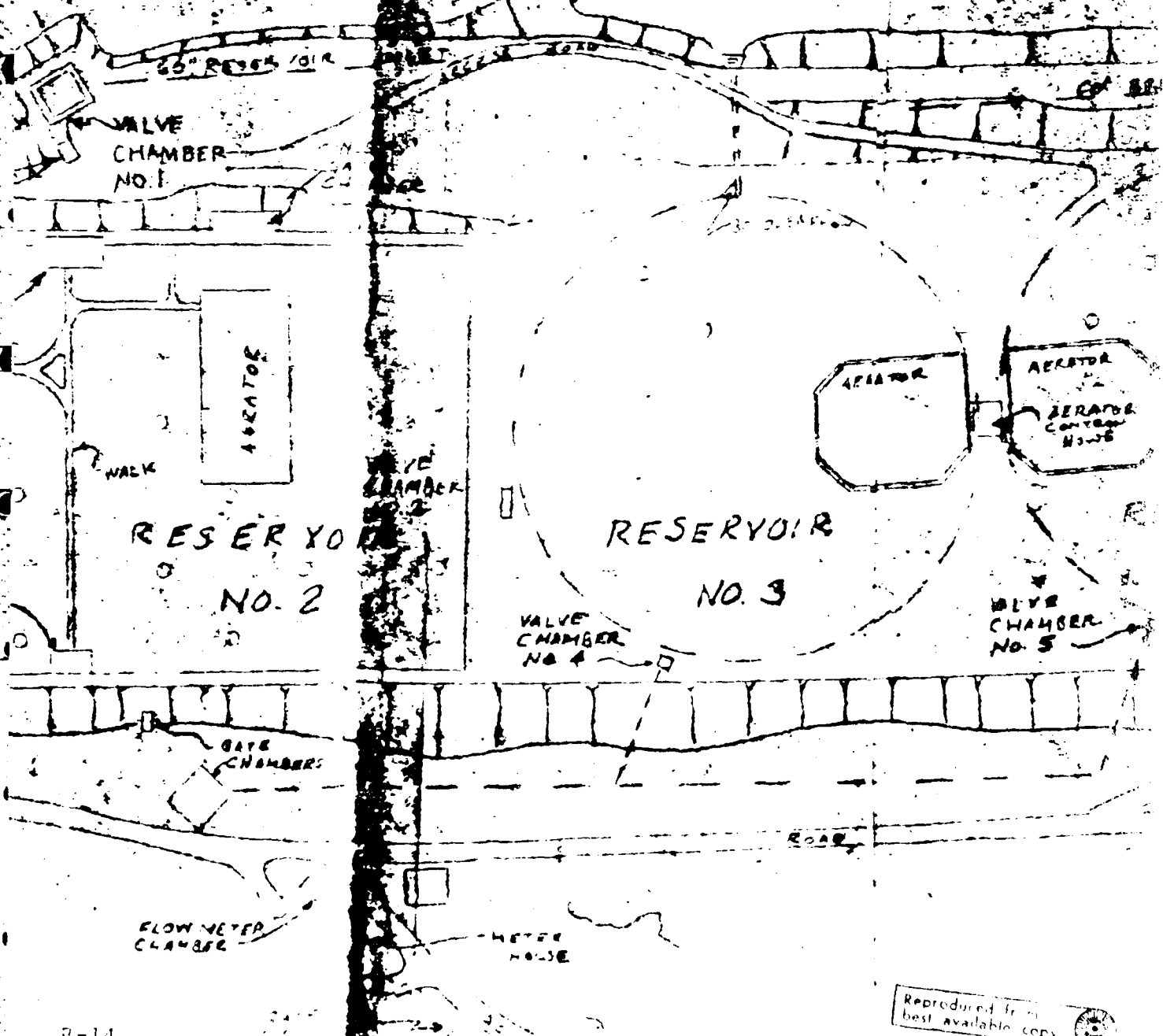


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B-14

INLET AQUEDUCT



3-14

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LOCUS PLAN

WESTFIELD

RIVER

MOUNTAIN

Brook

ADJACENT

CITY

Hill

Feeding H

Hornet Corner

DAM 2-7-5-70

120

LOCUS PLAN

WESTFIELD

RIVER

MOUNTAIN

Brook

ADJACENT

CITY

Hill

Feeding H.

Hornet Corner

Hornet

DAM 2-7-5-70

LOCUS PLAN

WESTFIELD

RIVER

MOUNTAIN

Brook

ADJACENT

CITY

SWISFIELD

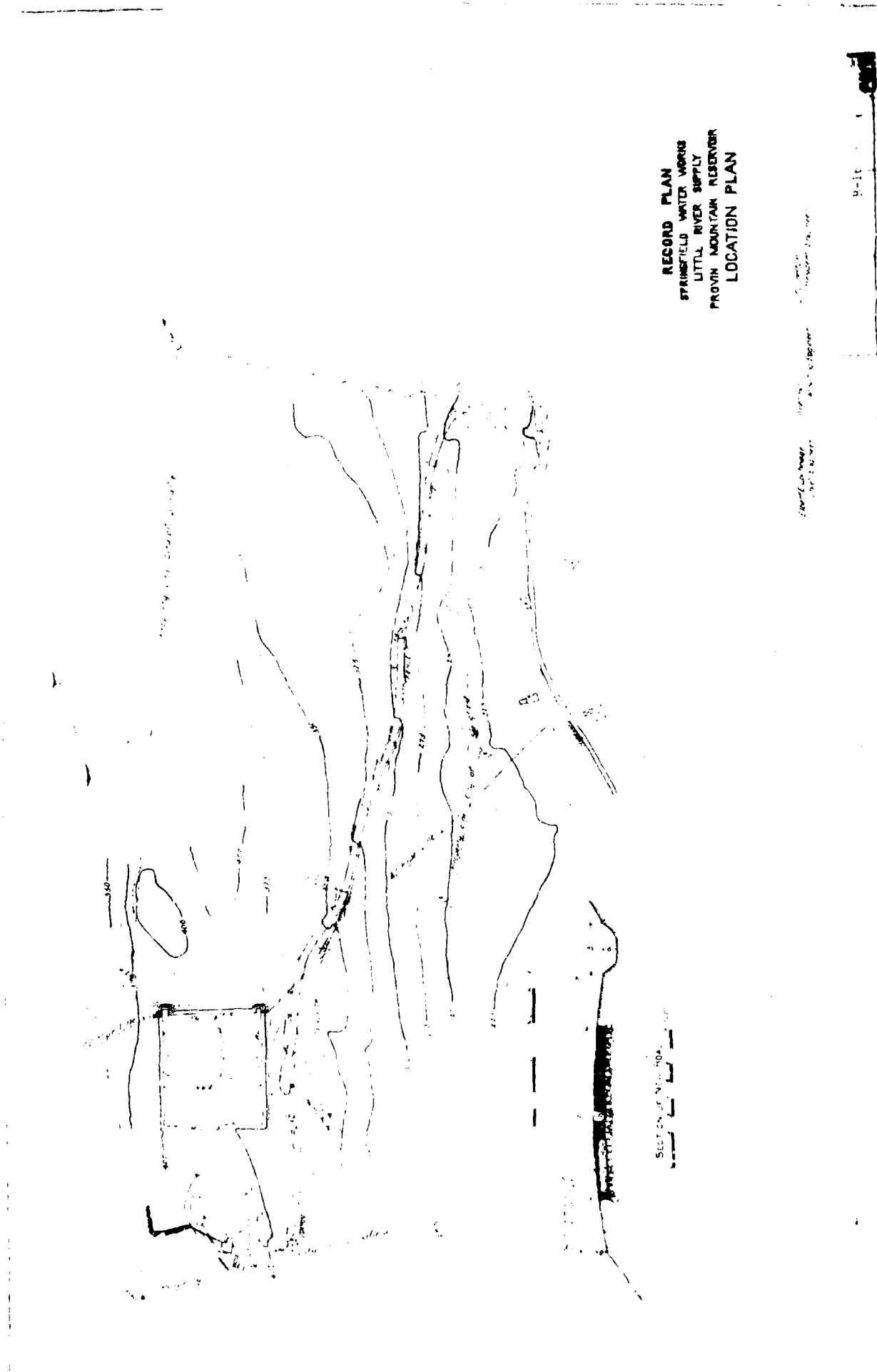
Feeding H.

Hosmer Corner

Johnson Corner

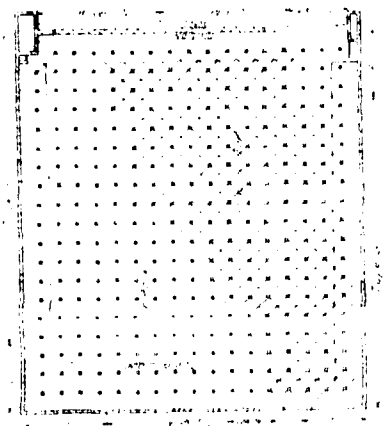
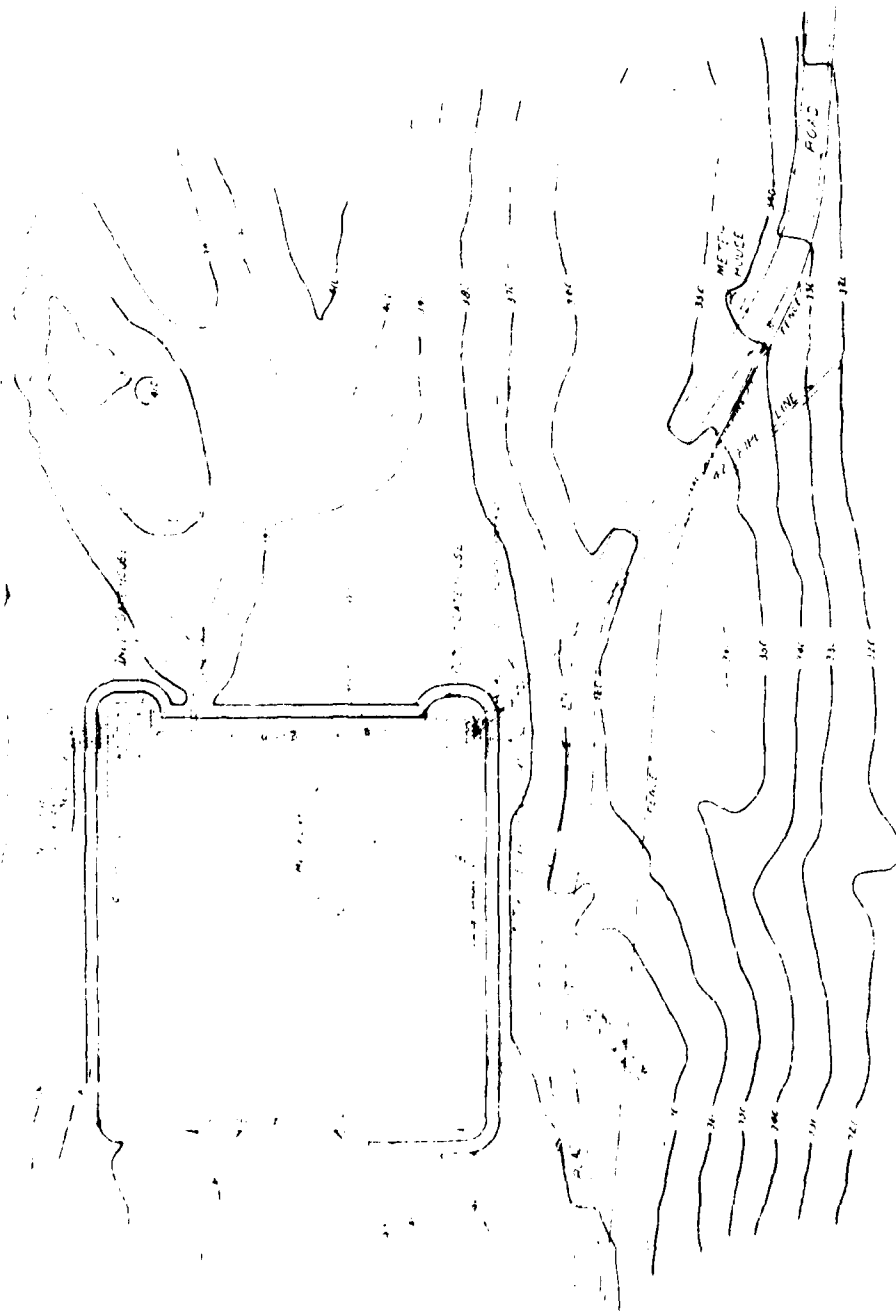
DAM #2-7-5-70

120



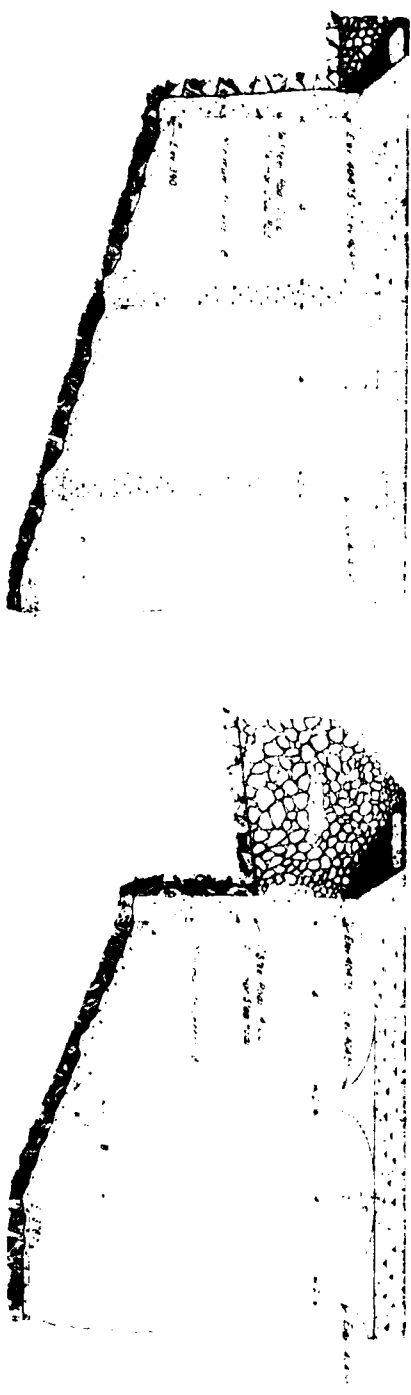
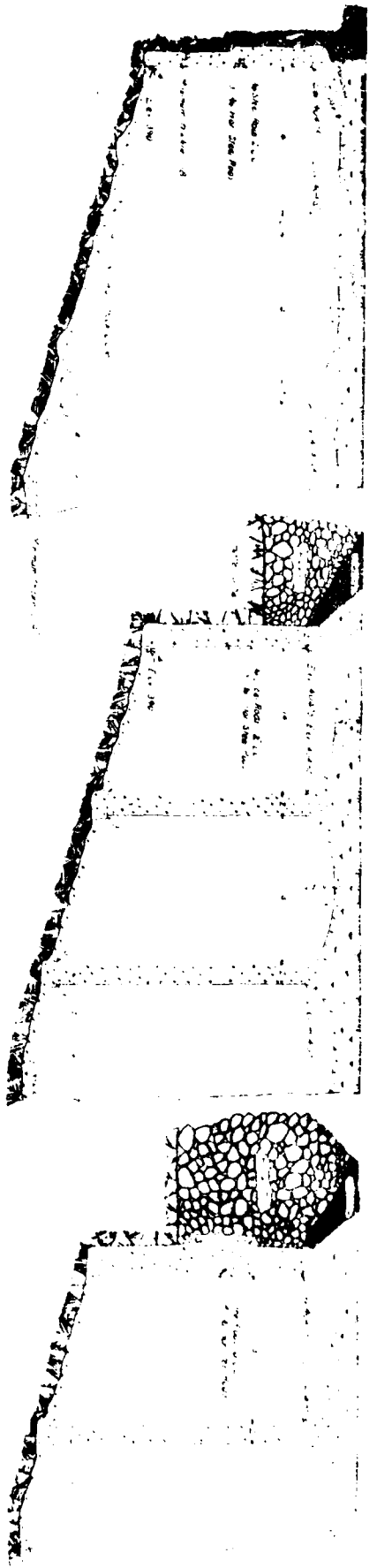
RECORD PLAN
SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
PROVIN MOUNTAIN RESERVOIR
LOCATION PLAN

SECTION OF NEW ROAD



RECORD PLAN
SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
PROVIN MOUNTAIN RESERVOIR
CONTOUR PLAN

DESIGNED BY: [Name]
 DRAWN BY: [Name]
 CHECKED BY: [Name]
 APPROVED BY: [Name]



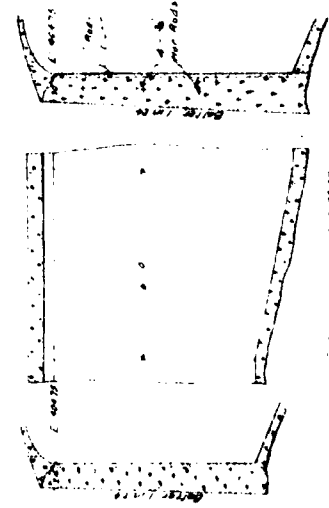
RECORD PLAN
 SPRINGFIELD WATER WORKS
 LITTLE RIVER SUPPLY
 PROVIN MOUNTAIN RESERVOIR
 TYPICAL SECTIONS OF WALLS



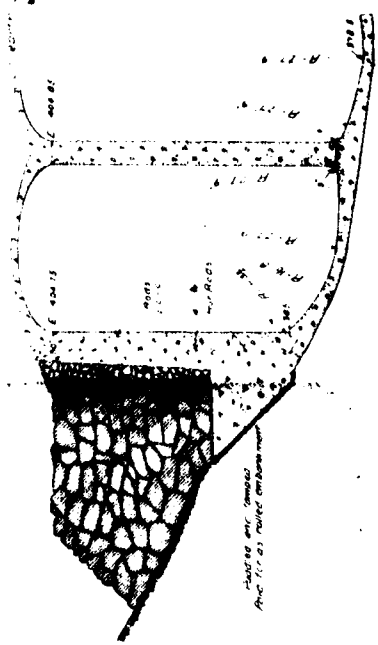
DEVELOPMENT OF EMBANKMENT



TYPE F



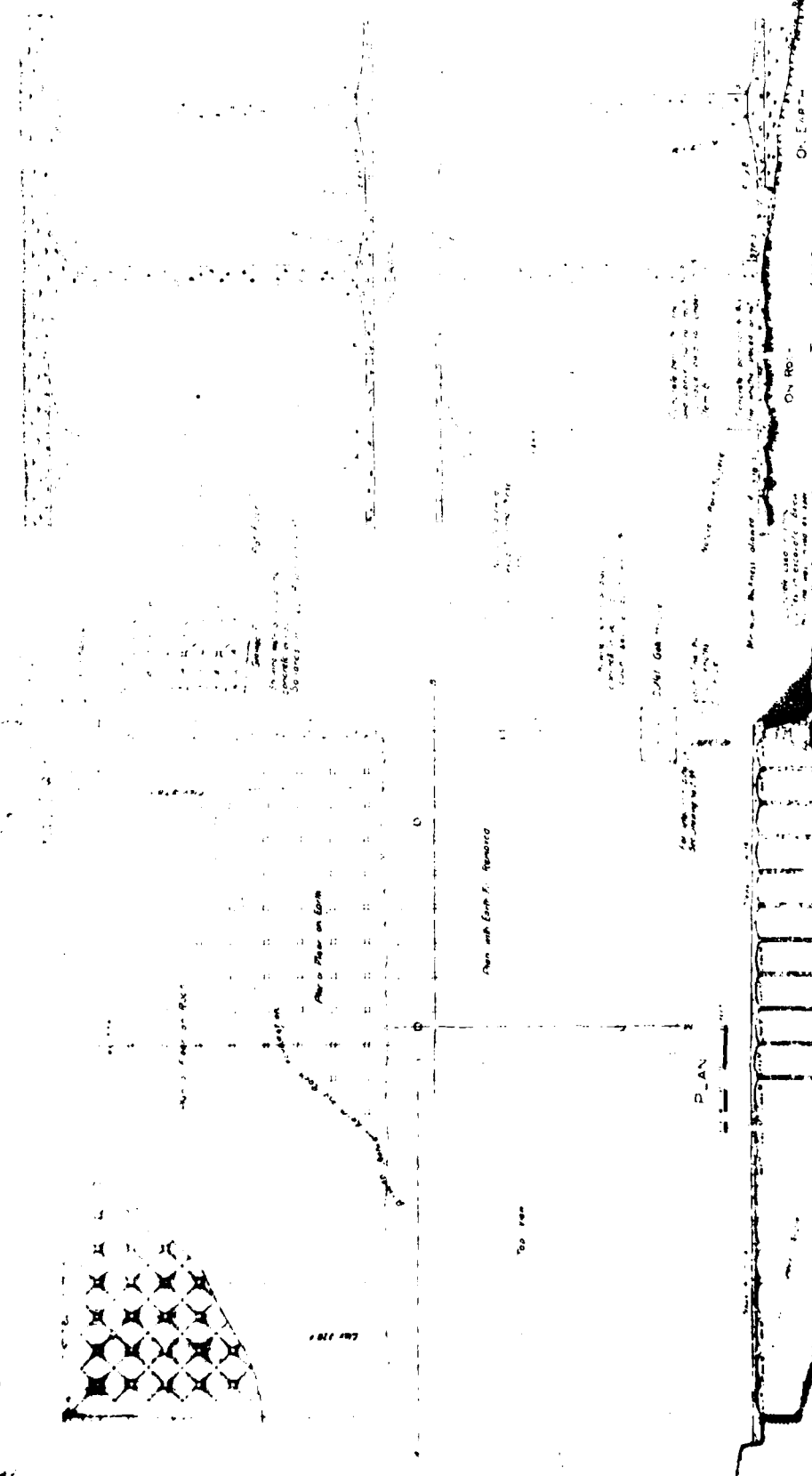
TYPE G



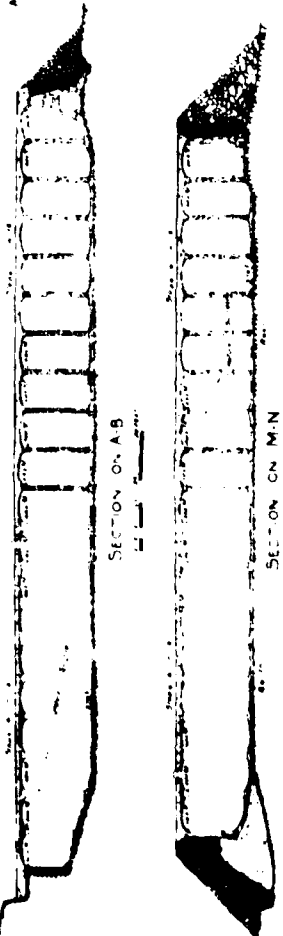
TYPE H

TYPE I

RECORD PLAN
SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
PROVIN MOUNTAIN RESERVOIR
TYPICAL SECTIONS OF WALLS



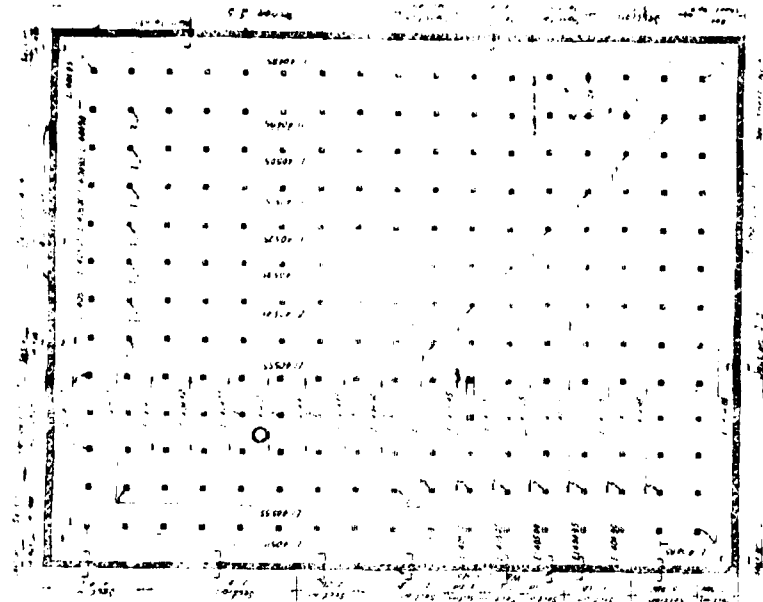
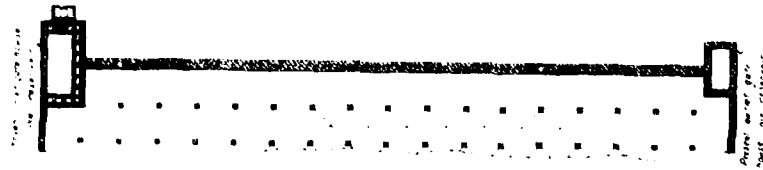
RECORD PLAN
 SPRINGFIELD WATER WORKS
 LITTLE RIVER SUPPLY
 PROVIN MOUNTAIN RESERVOIR
 GENERAL PLAN AND SECTIONS



Engineer
 Consulting Engineer
 Resident Engineer

Scale: 1" = 100' (Horizontal)
 1" = 10' (Vertical)

SHEET NO. 1



PLAN SHOWING ELEVATIONS OF PIERS AT SPRINGING LINE AND LOCATION OF SECTIONS

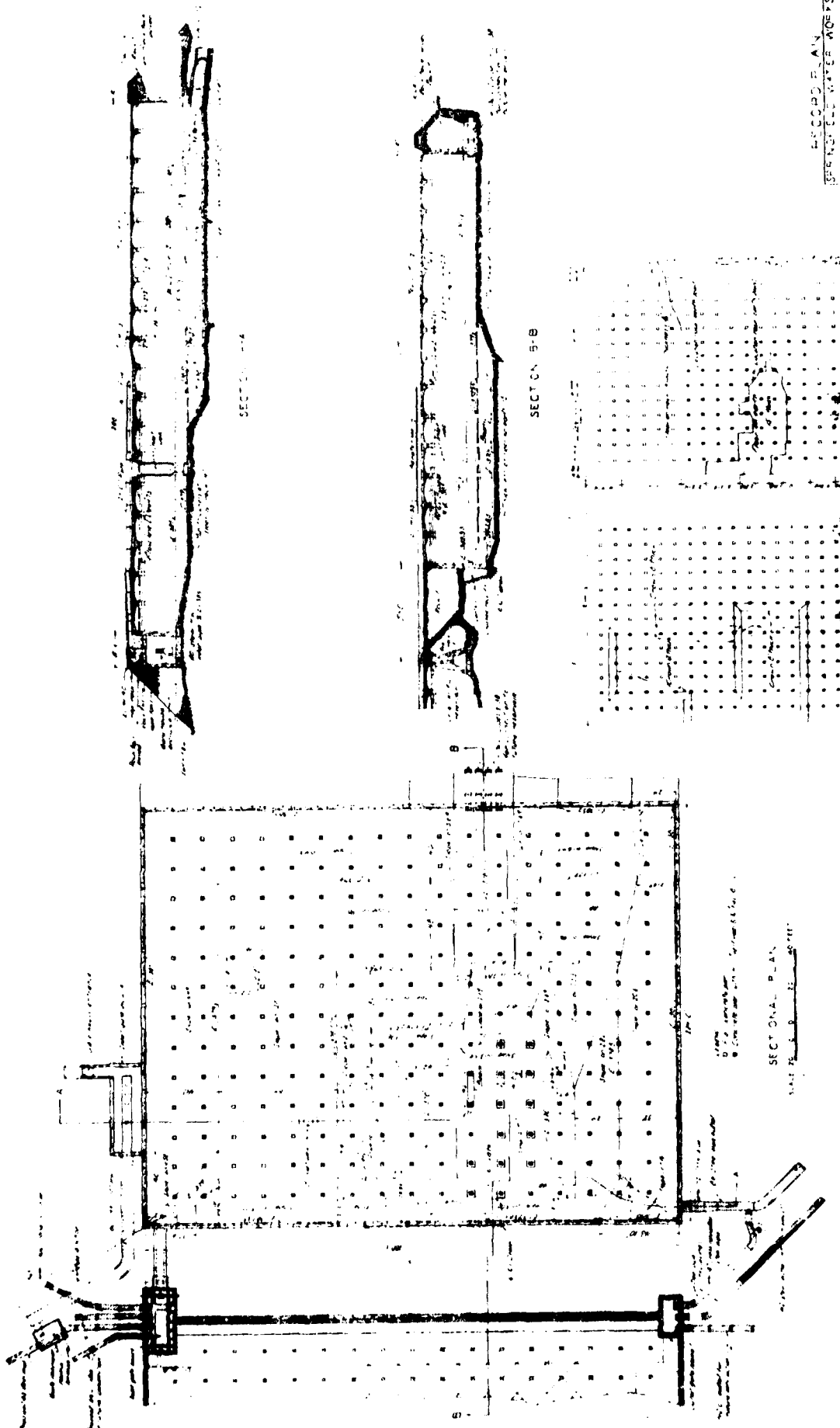
RECORD PLAN

SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO. 18
FROM MAY 1914
BY SERVICE

SCALE 1\"/>

RECORD PLAN

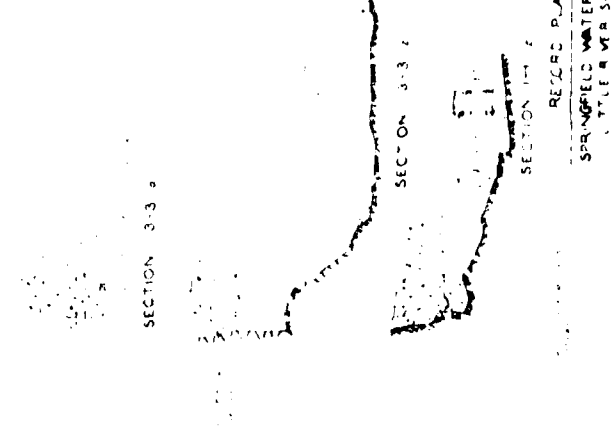
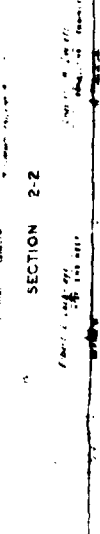
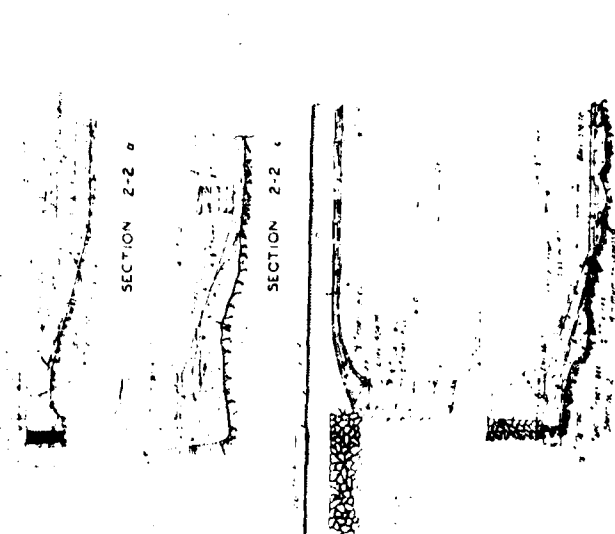
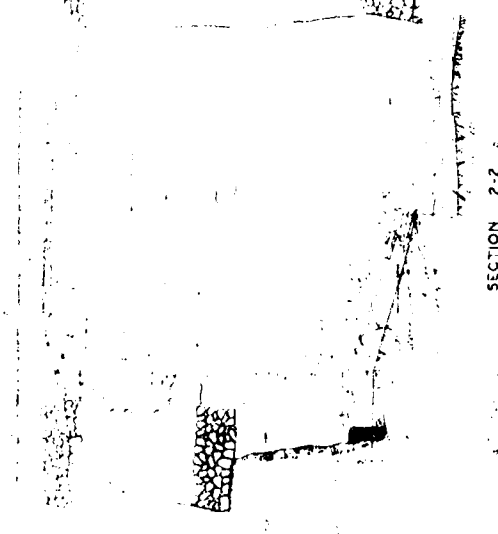
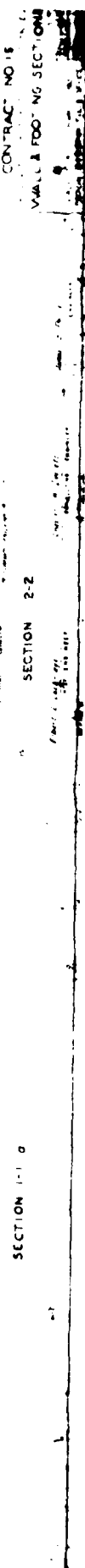
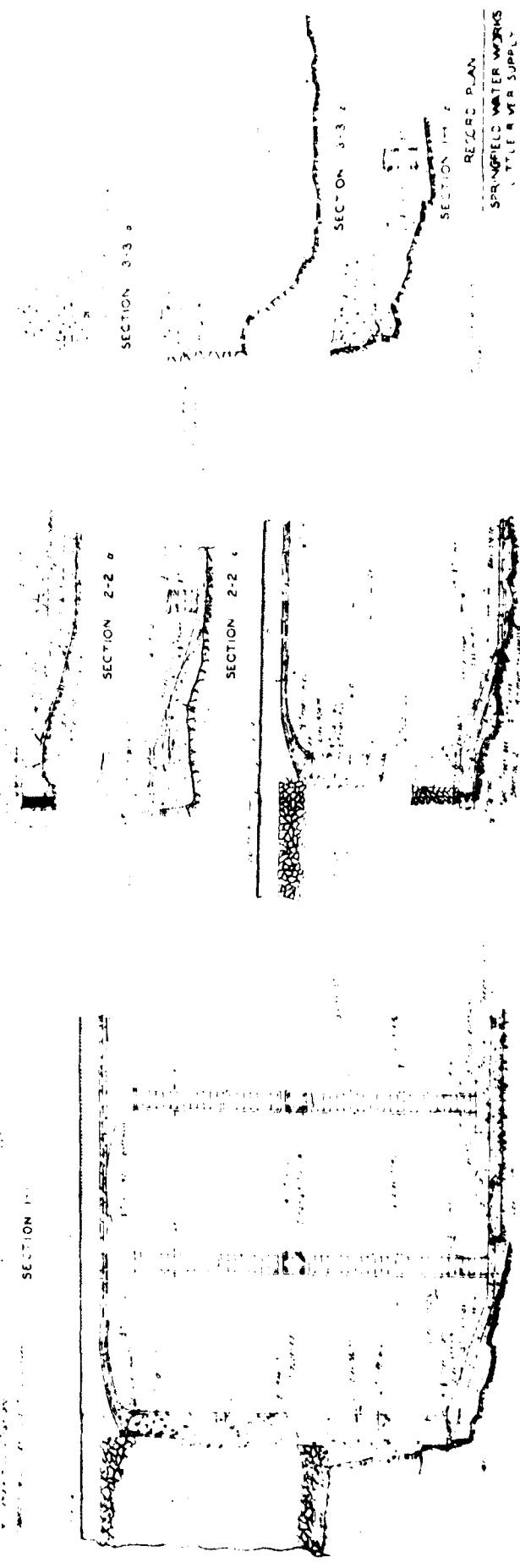
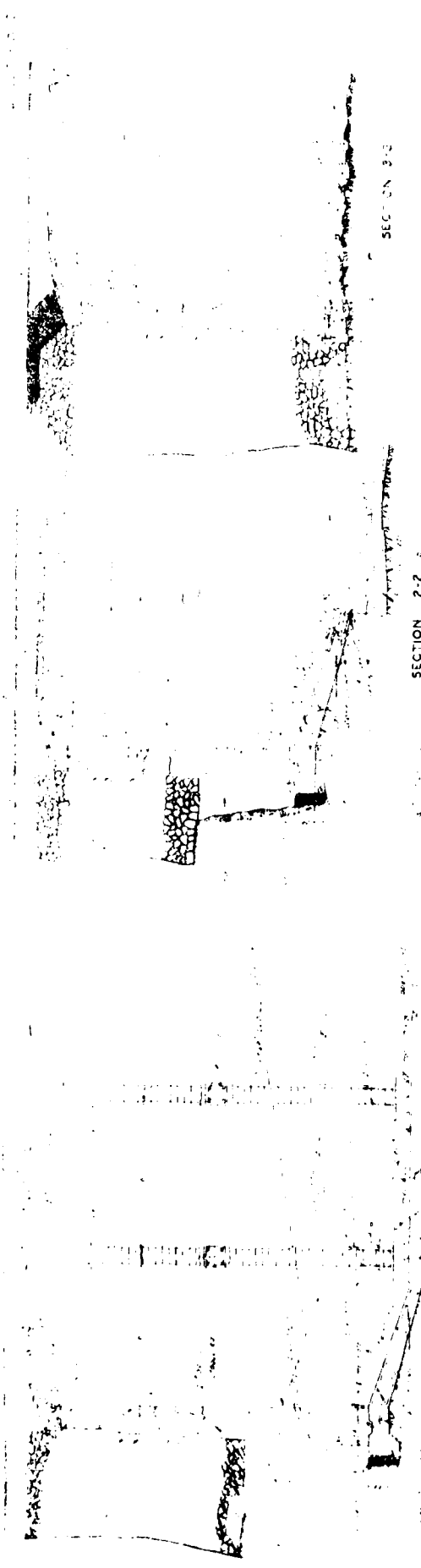
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RECORD PLAN
SPRINKLER WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO. 15
PLAN AND SECTION
GENERAL PLANS

SECTIONAL PLAN
SCALE 1/8" = 1'-0"

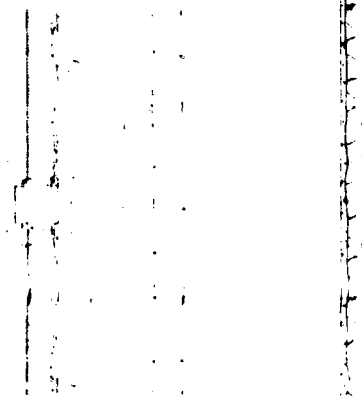
FLOOR PLAN
SCALE 1/8" = 1'-0"



RECORD PLAN
 SPRINGFIELD WATER WORKS
 TITLE & WATER SUPPLY
 CONTRACT NO. 15
 WALL & FOOTING SECTIONS



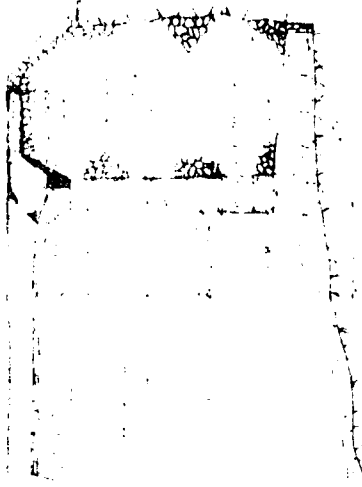
SECTION 4-4



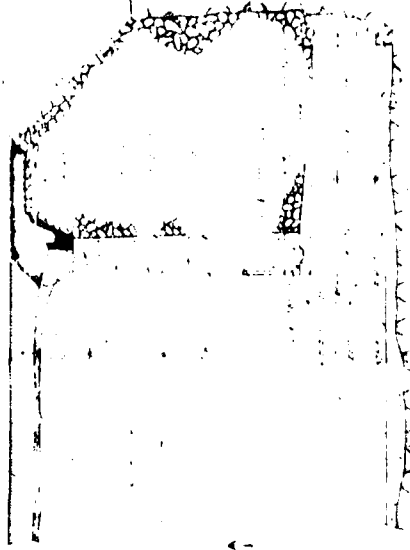
SECTION 4-4

SECTION 4-4

TYPICAL SECTION OF VAULTING
SHOWING MANHOLE



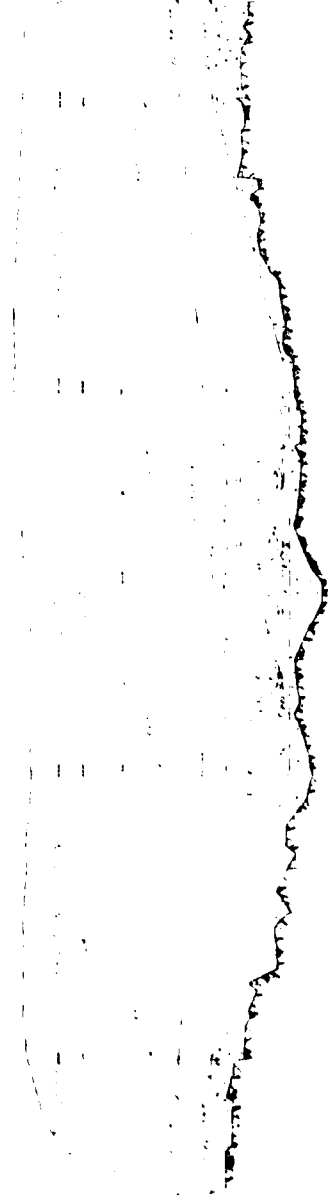
SECTION 5-5



SECTION 6-6

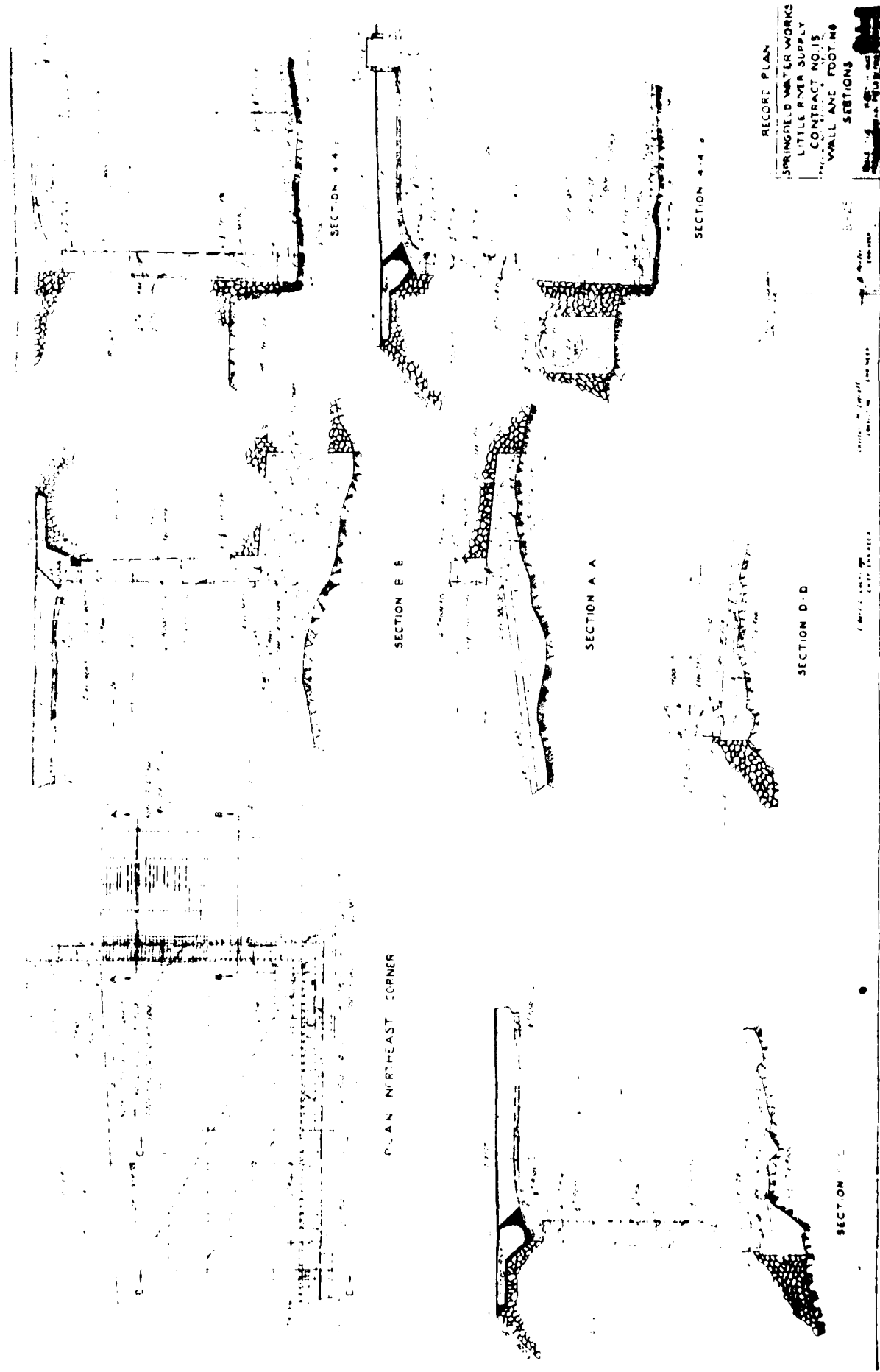
A. The structure shown in this section is a typical example of the type of vaulting used in the construction of the Little River Supply System. It is a semi-circular vault with a flat base and a small rectangular opening at the top center. The vault is constructed of concrete and is supported by a foundation of concrete. The vault is shown in cross-section to illustrate its construction and the location of the manhole.

FUTURE CONNECTION
SECTIONAL PLAN AT SPRINGLINE



SECTION A-A

RECORD PLAN
SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO. 15
WALL & FOOTING SECTIONS



RECORD PLAN
SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO. 15
WALL AND FOOTING
SECTIONS

PLAN NORTHEAST CORNER

SECTION A-A

SECTION B-B

SECTION C-C

SECTION D-D

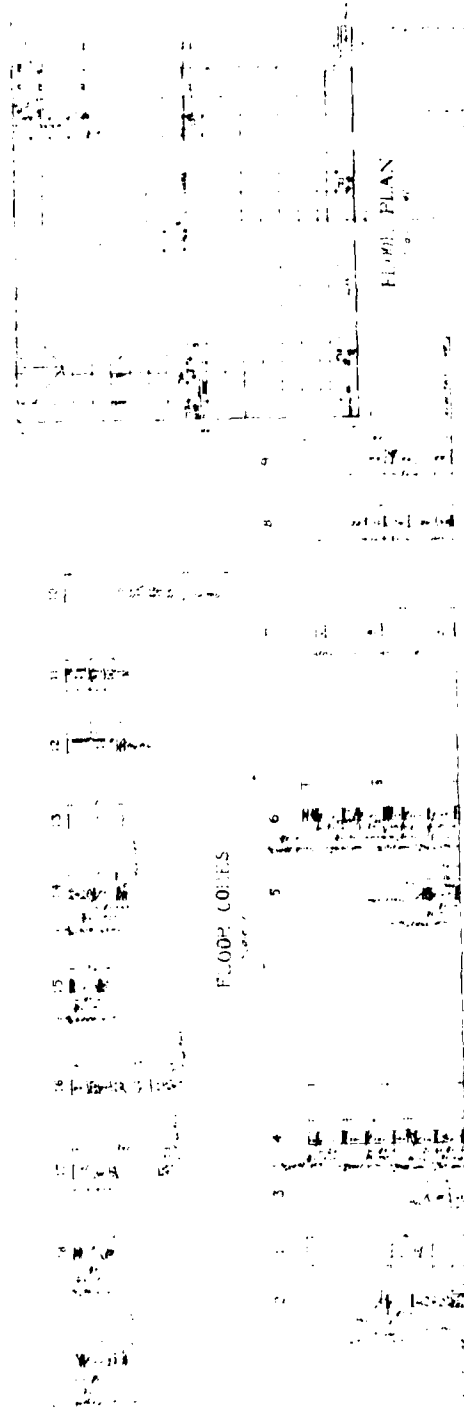
SECTION E-E

SECTION F-F



ROOF PLAN

ELEV. EAST WALL



FLOOR CORERS

FLOOR PLAN

ELEV. WEST WALL

SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
PLOW MOUNTAIN RESERVE
CEMENT MILL NO. 912 AM
RESULTS OF CONCRETE
TESTS

DETAILS

10-11-50

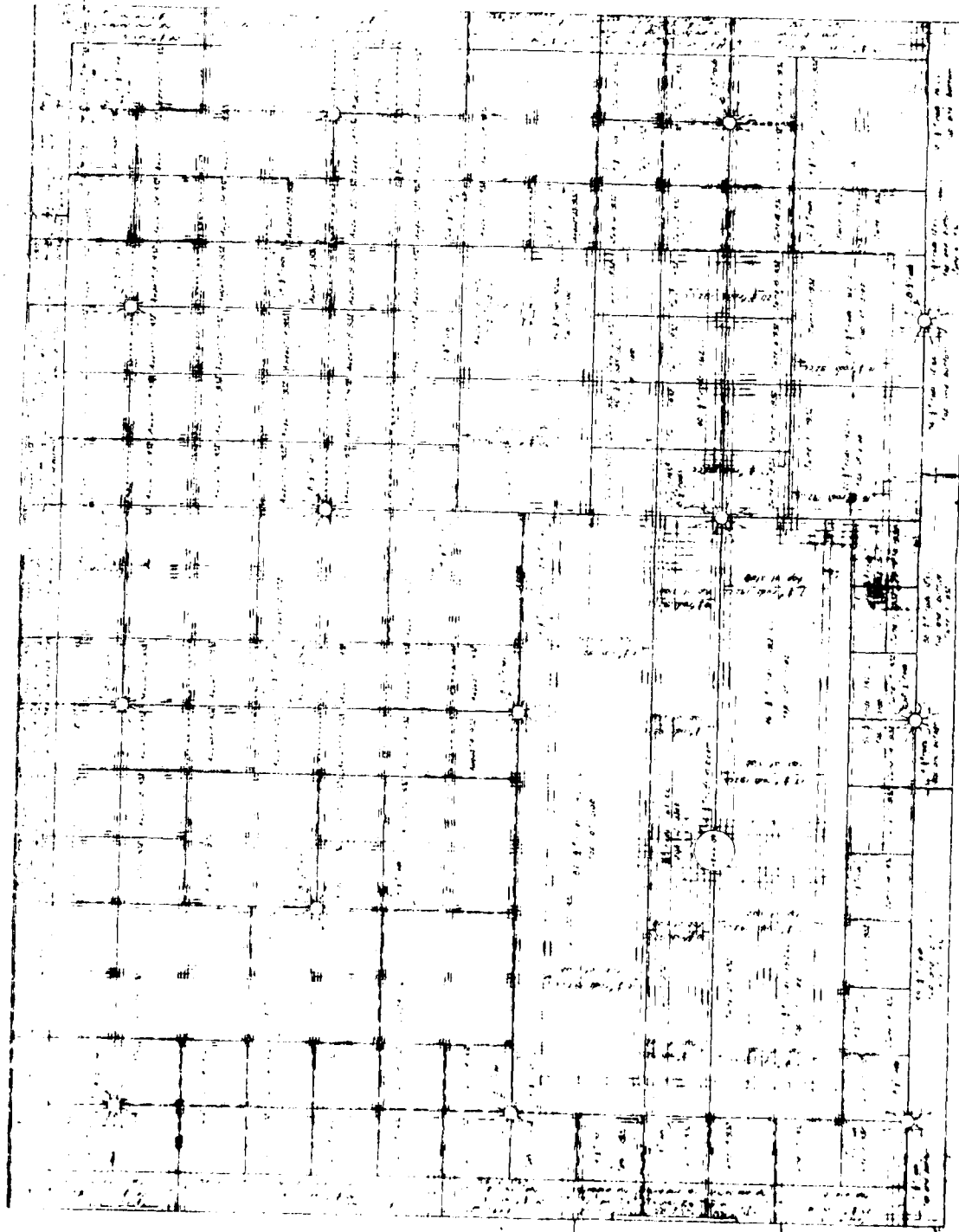


RECORD PLAN
SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO. 5
FLOOR STEEL
B-28

10-25

RECORD PLAN

SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO. 18
PROVIN MOUNTAIN RESERVOIR
RESERVOIR SECTION 2
ROOF

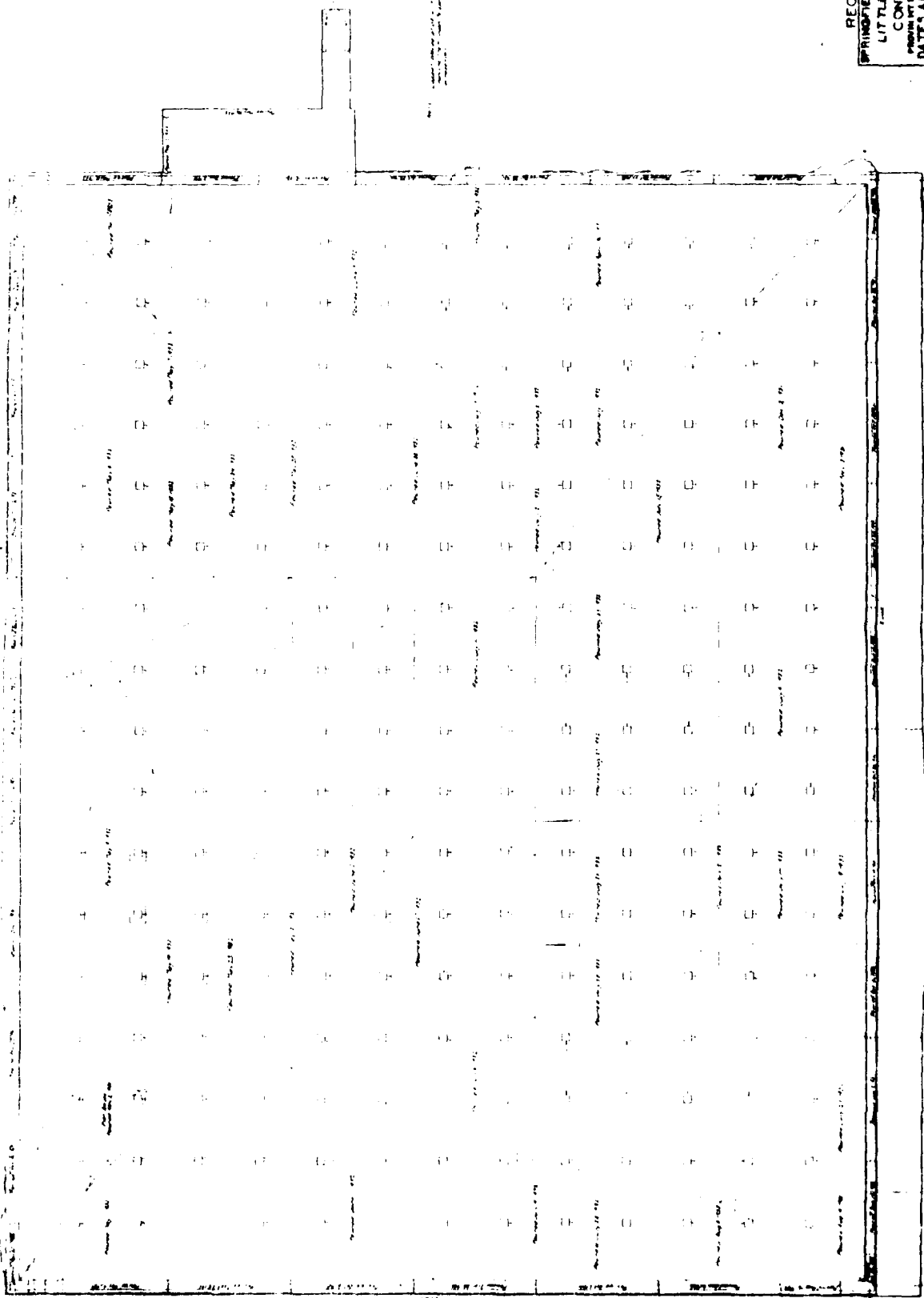


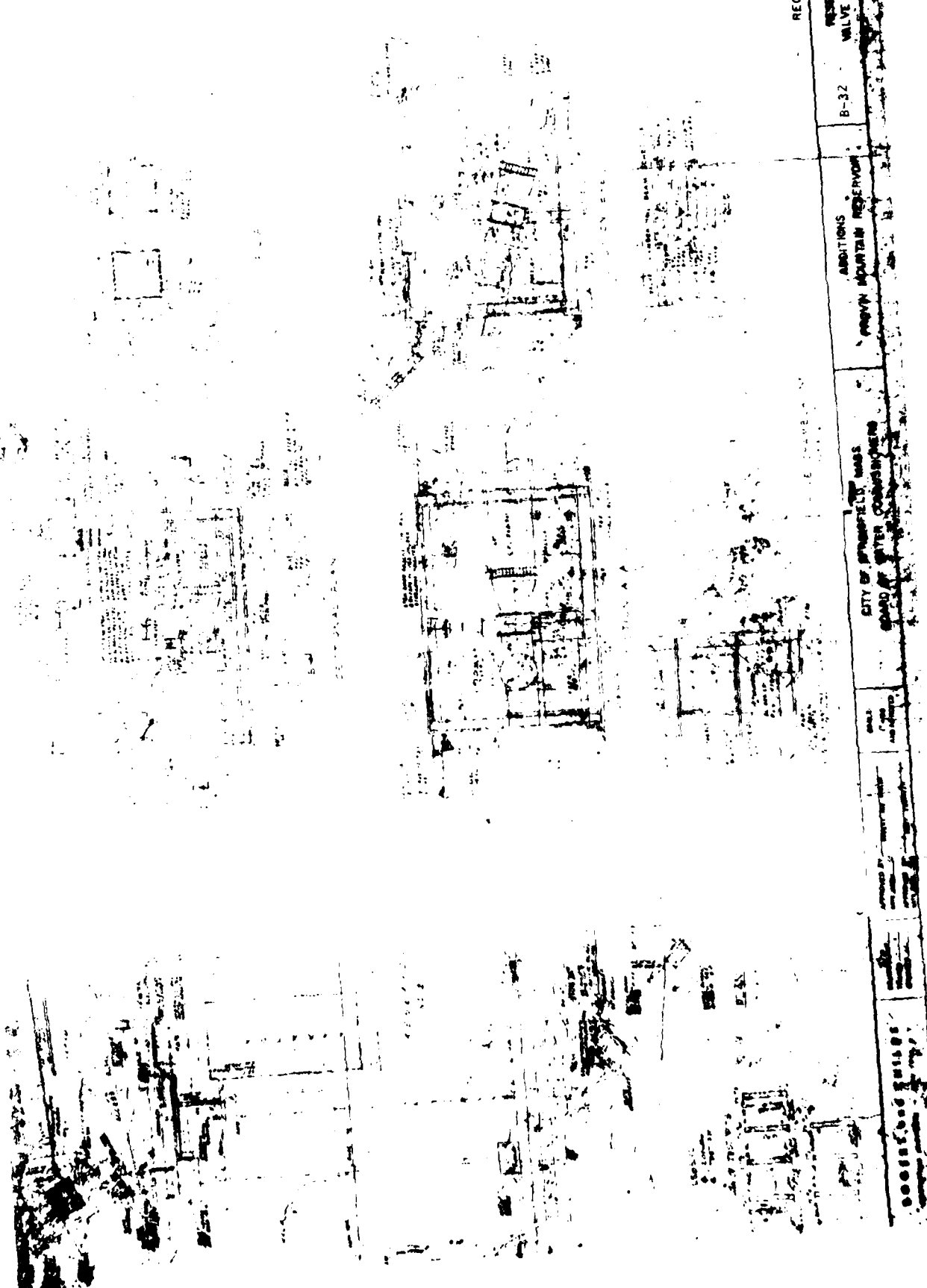
PLAN OF ROOF REINFORCING

10-25

RECORD PLAN
SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO. 18
FURNISHING AND INSTALLING
DAM, AND LOCATIONS
WALL AND GATE PILES

B-31





CONTRACT 43
RECORD DRAWING NO. 2

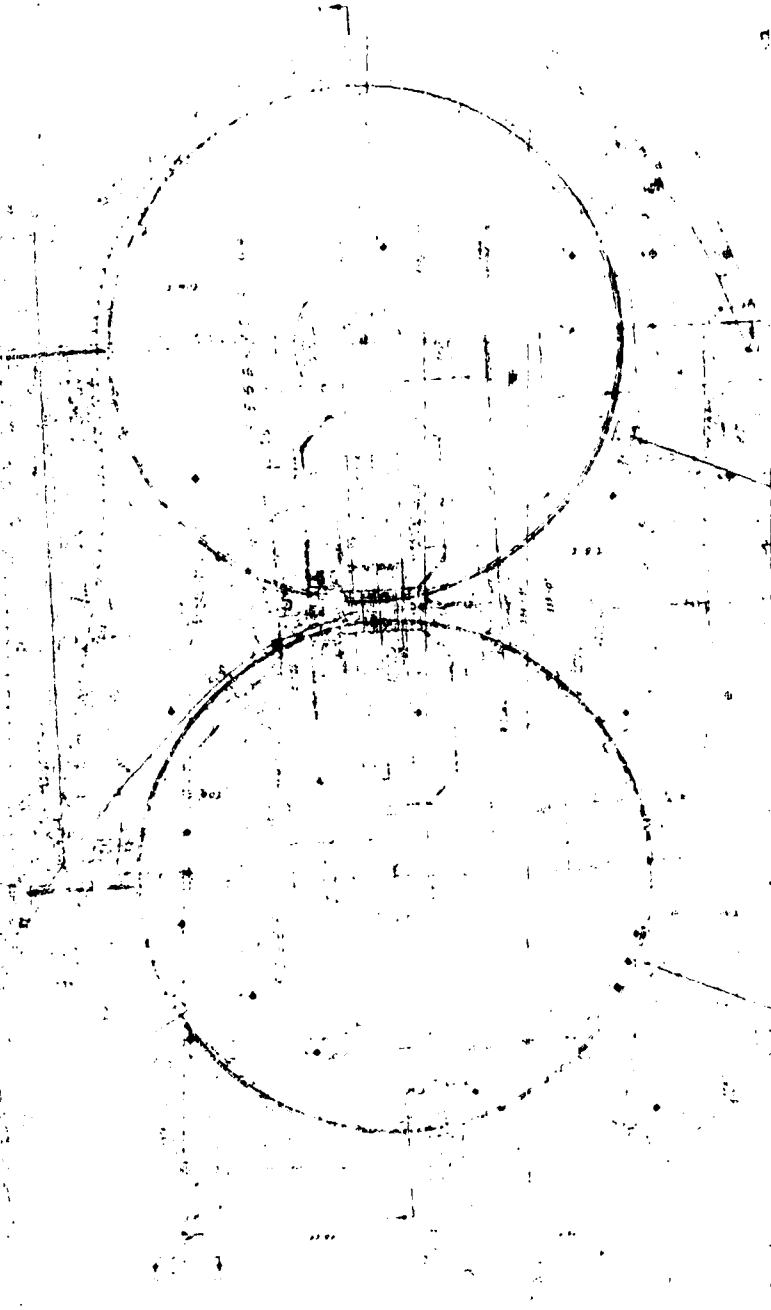
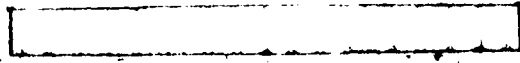
B-32 RESERVOIR NO. 18
VALVE CHAMBER NO. 1

ADDITIONS
MOUNTAIN RESERVOIR

CITY OF SPRINGFIELD, MASS.
BOARD OF WATER COMMISSIONERS

Scale: 1" = 100'

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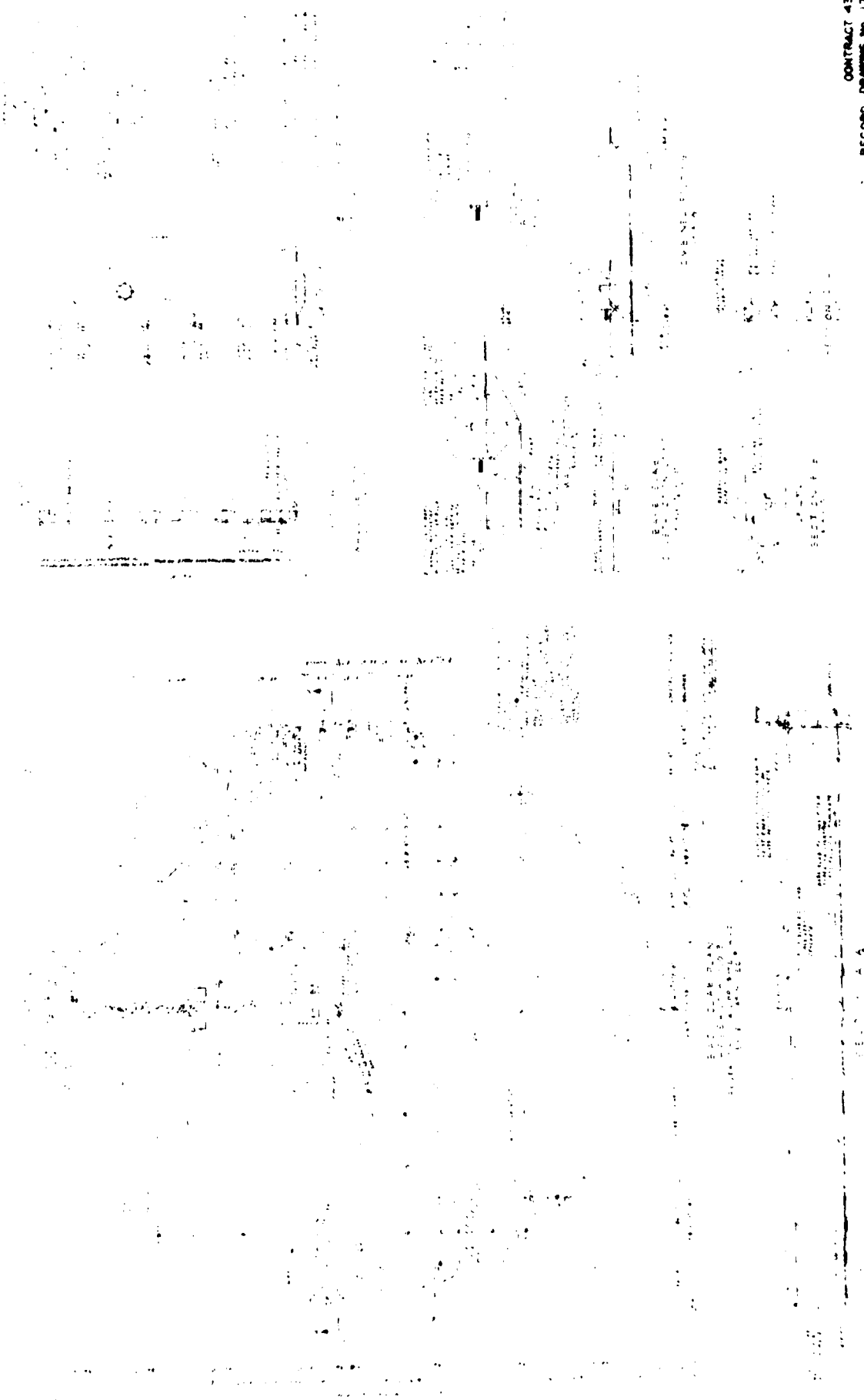


CONTRACT 43
RECORD DRAWING NO. 3

E-33

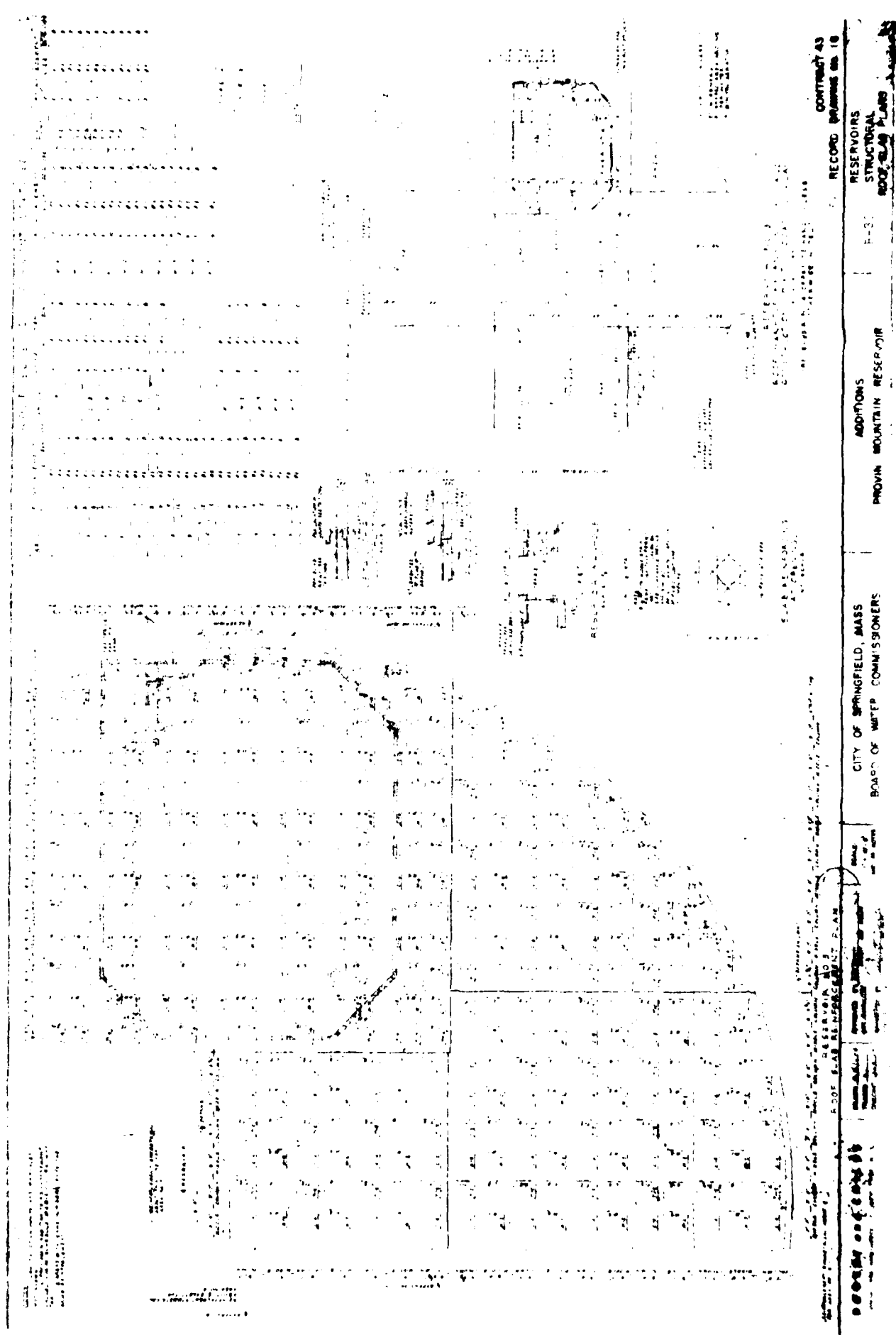
DESIGNER CHILDS	DATE 1910	SCALE 1" = 100'	CITY OF SPRINGFIELD, MASS. BOARD OF WATER COMMISSIONERS	ADDITIONS PROVIN MOUNTAIN RESERVOIR	RESERVOIRS GENERAL PLAN AND SECTIONS
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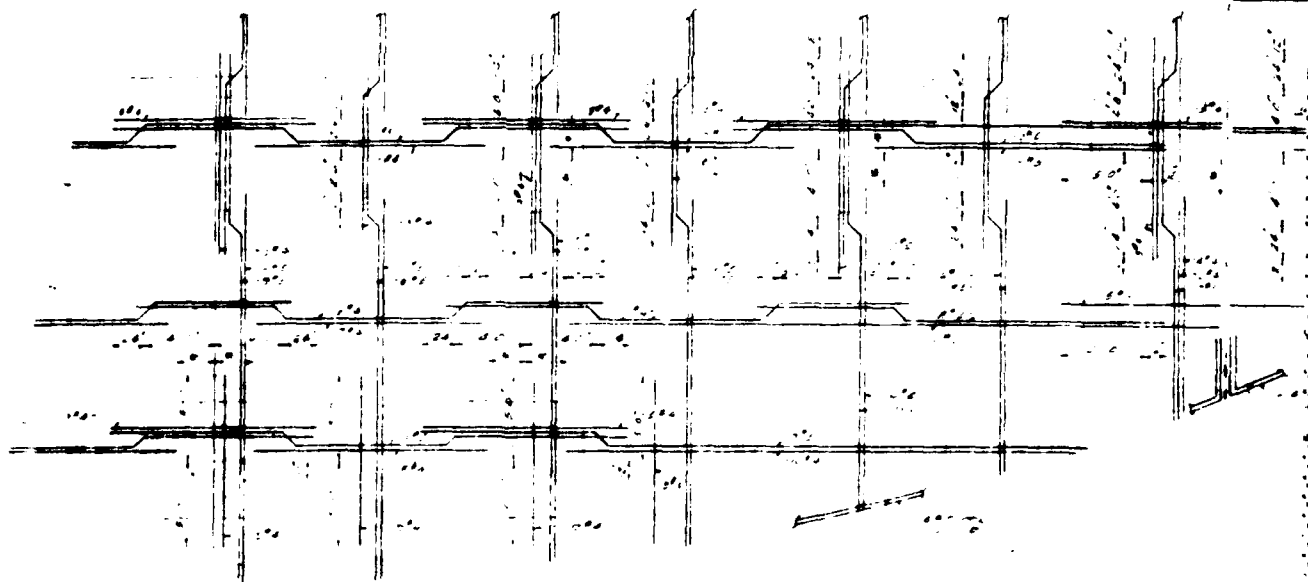


CONTRACT 43		RECORD DRAWING NO. 17	
B-34		RESERVOIRS	
B-35		STRUCTURAL	
B-36		ADDITIONS	
B-37		MOUNTAIN BECK	
B-38		CITY OF SPRINGFIELD, MASS	
B-39		AGENCY OF WATER COMMISSIONERS	
B-40		SCALE	
B-41		APPROVED BY	
B-42		DESIGNED BY	
B-43		CHECKED BY	
B-44		DRAWN BY	
B-45		DATE	
B-46		PROJECT NO.	
B-47		SHEET NO.	
B-48		CONTRACT NO.	
B-49		RECORD DRAWING NO.	
B-50		B-34	
B-51		B-35	
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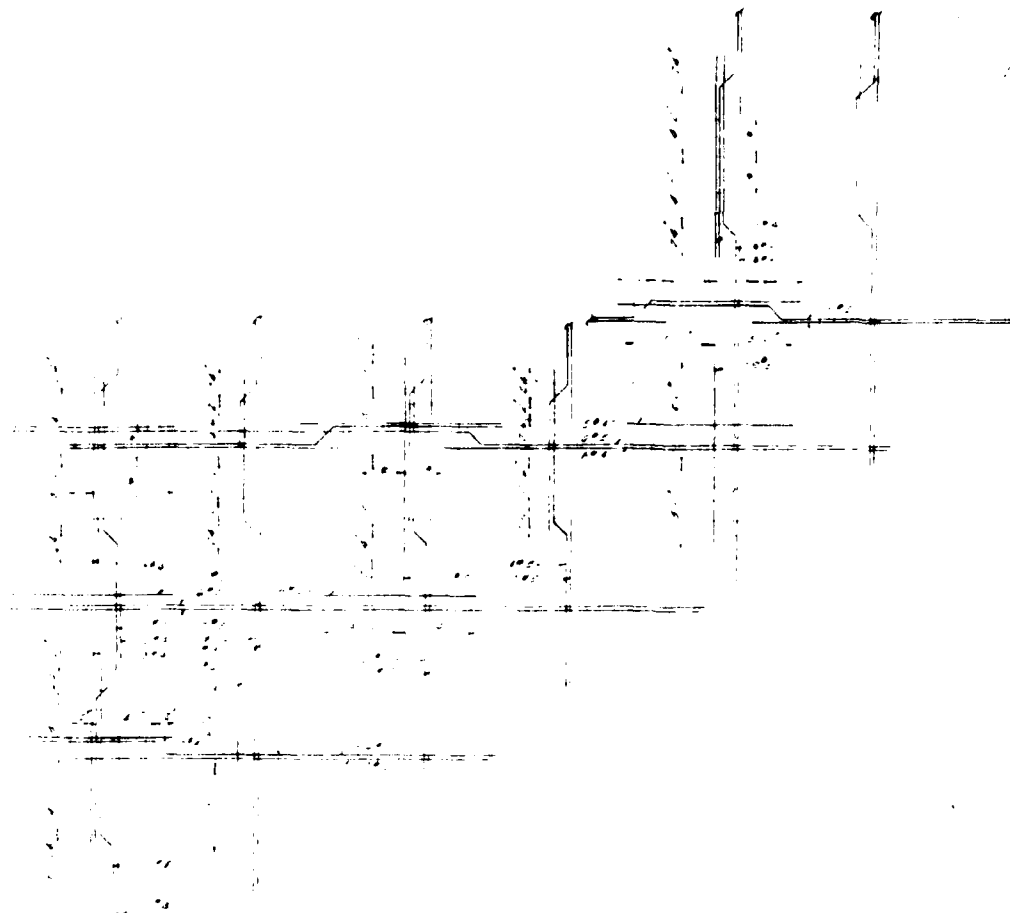
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PART PLAN RESERVOIR NO. 3
AREA 2

152

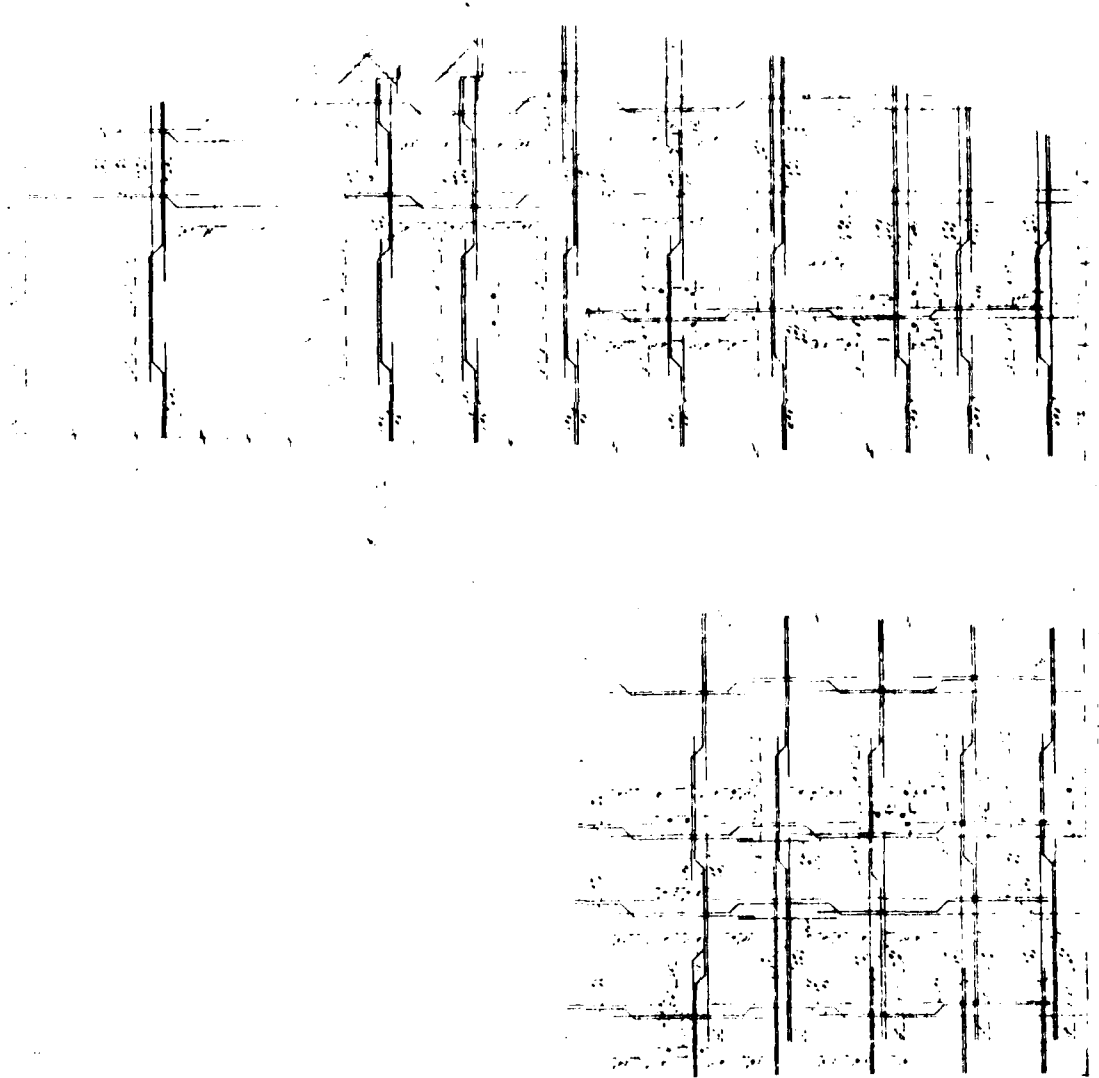
BOGERT and CHILDS CONSULTING ENGINEERS • NEW YORK, N. Y.	DRAWN <u>5</u> TRACED <u>5</u> CHECKED <u>5</u>	APPROVED BY _____ DATE _____	SCALE 4" = 100'	CITY OF SPRINGFIELD BOARD OF WATER COMMISSIONERS
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CONTRACT 43
 (547) RECORD DRAWING No. 19

OLD MASS BAY BUILDERS	ADDITIONAL POLY MOUNTAIN RESERVOIR	B-36 RESERVOIR STRUCTURAL ROOF SLAB REINFORCEMENT BENDING DETAILS
--------------------------	---------------------------------------	--



CONTRACT 43
(64) RECORD DRAWING No. 20

RESERVED
B-37 STRUCTURAL

SECTION

SECTION OF BRIDGE PIER, MASS

SCALE

DATE

DOBBY and CHILDS
Engineers and Architects
100 N. 1st St., St. Paul, Minn.

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DECEMBER 1960

11

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BOARD OF WATER COMMISSIONERS

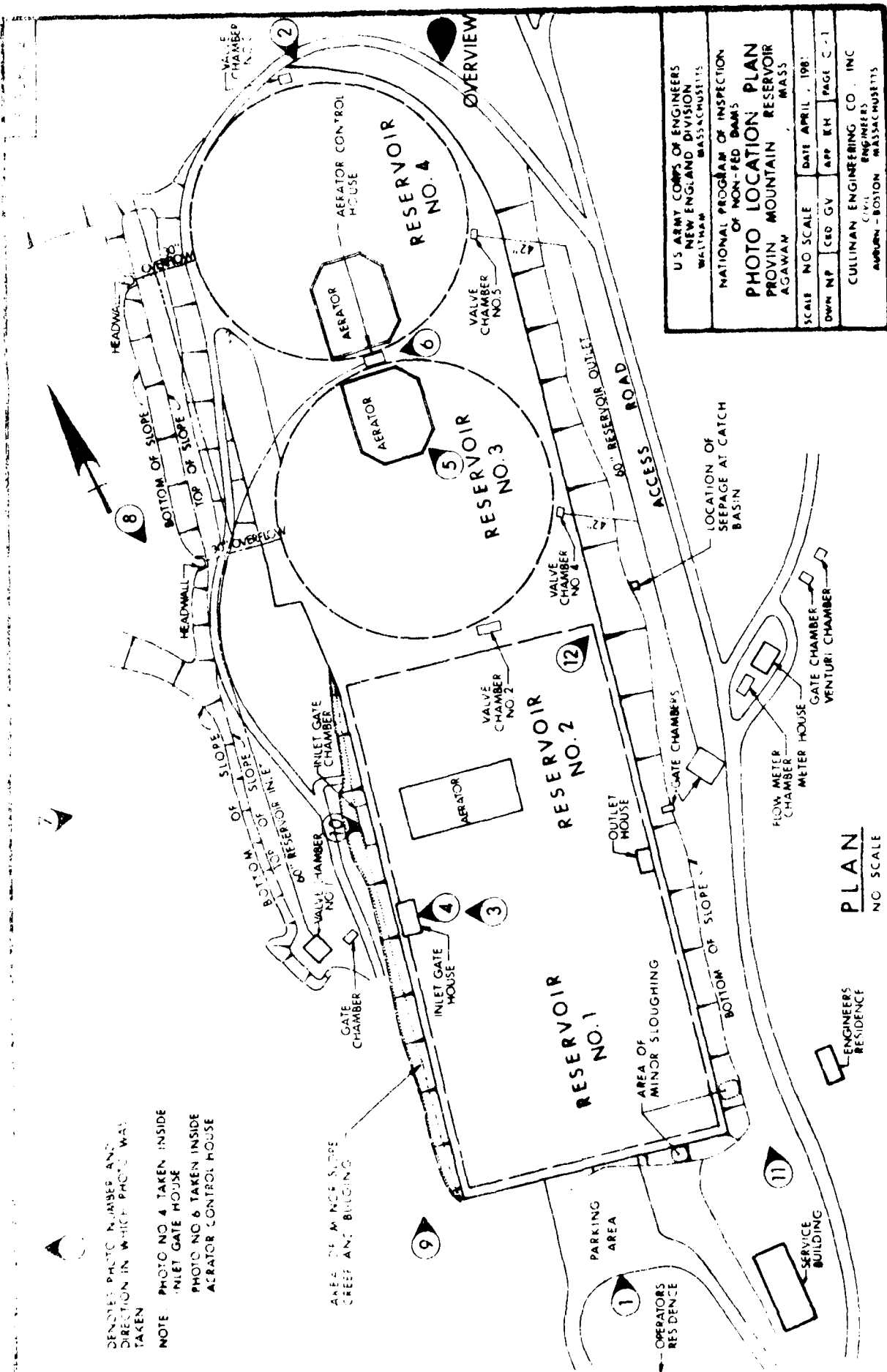
ADDITIONS
BROWN MOUNTAIN R

E-39

RESEARCH
TRUCKING

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APPENDIX C
PHOTOGRAPHS



DENOTES PHOTO NUMBER AND
 DIRECTION IN WHICH PHOTO WAS
 TAKEN
 NOTE
 PHOTO NO. 4 TAKEN INSIDE
 INLET GATE HOUSE
 PHOTO NO. 6 TAKEN INSIDE
 AERATOR CONTROL HOUSE

U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION WALTHAM		NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS	
PHOTO LOCATION PLAN		PROVIN MOUNTAIN RESERVOIR AGAWAM MASS	
SCALE	NO SCALE	DATE	APRIL 1981
DWN NP	CRD GV	APP	EH
CULLINAN ENGINEERING CO., INC.		PAGE C-1	
AMHERST - BOSTON MASSACHUSETTS			

PLAN
 NO SCALE

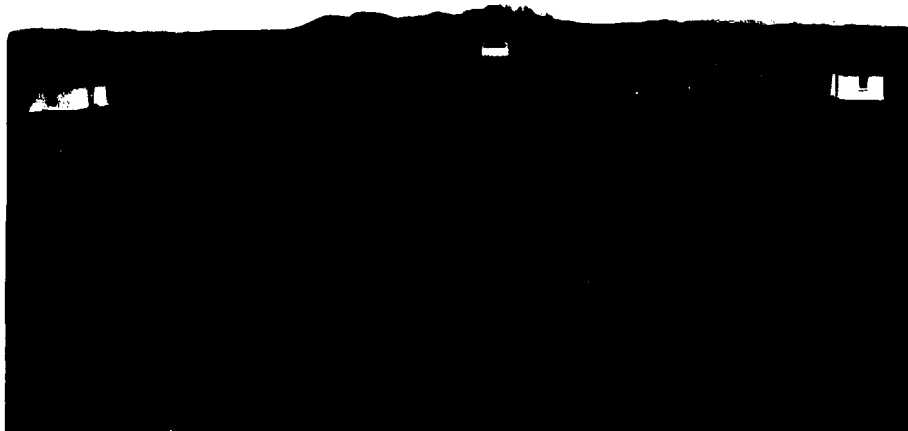


PHOTO NO. 1
VIEW OF TOP FROM SOUTH END



PHOTO NO. 2
VIEW OF TOP FROM NORTH END

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION
WALTHAM, MASSACHUSETTS

CULLINAN ENGINEERING CO., INC.
CIVIL ENGINEERS
AUBURN-BOSTON, MASSACHUSETTS

NATIONAL PROGRAM
OF INSPECTION
OF NON-FED. DAMS

Provin Mountain Reservoir
City of Springfield Aqueduct
Agawam, MA
MA 00528
March 4, 1981



PHOTO NO. 3
FRONT VIEW OF INLET GATE HOUSE



PHOTO NO. 4
VIEW INSIDE OF INLET GATE HOUSE

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION
WALTHAM, MASSACHUSETTS

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March 4, 1981

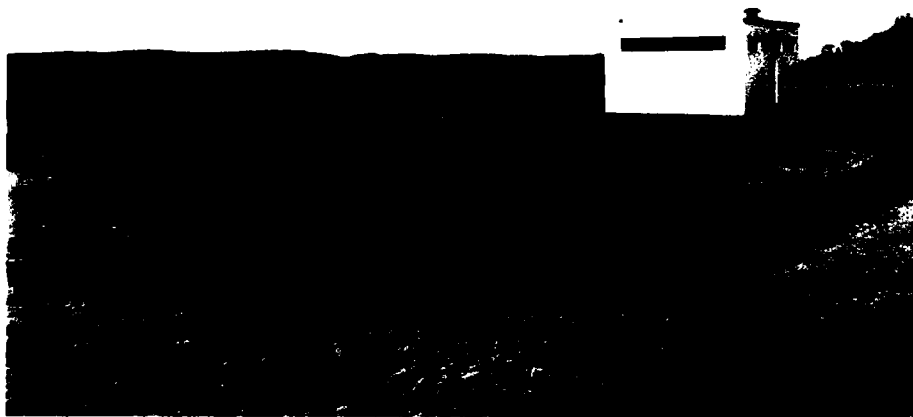


PHOTO NO. 5
VIEW AERATOR CONTROL HOUSE AND AERATORS
FORMERLY USED FOR RESERVOIRS NO. 3 & NO. 4

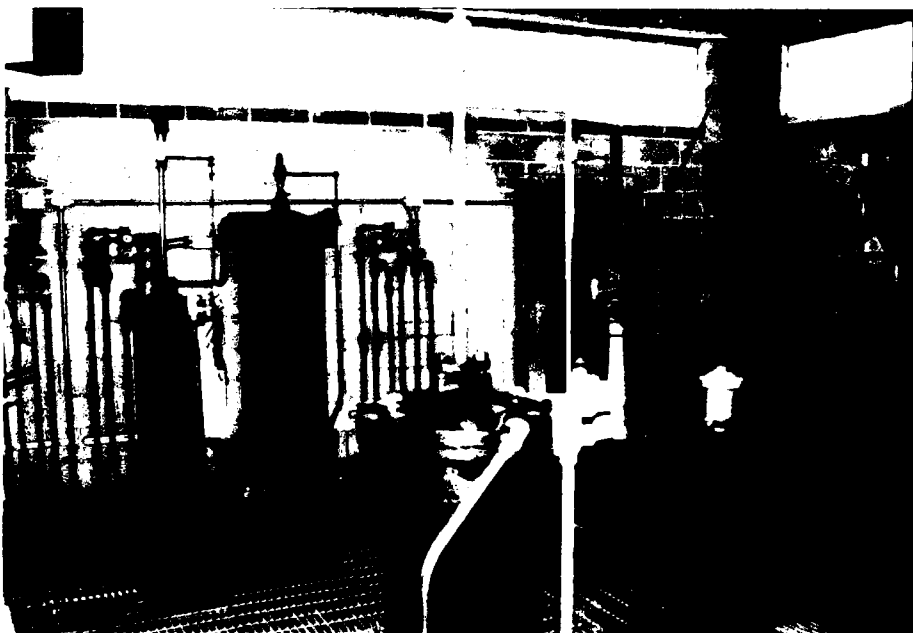


PHOTO NO. 6
VIEW INSIDE AERATOR CONTROL HOUSE

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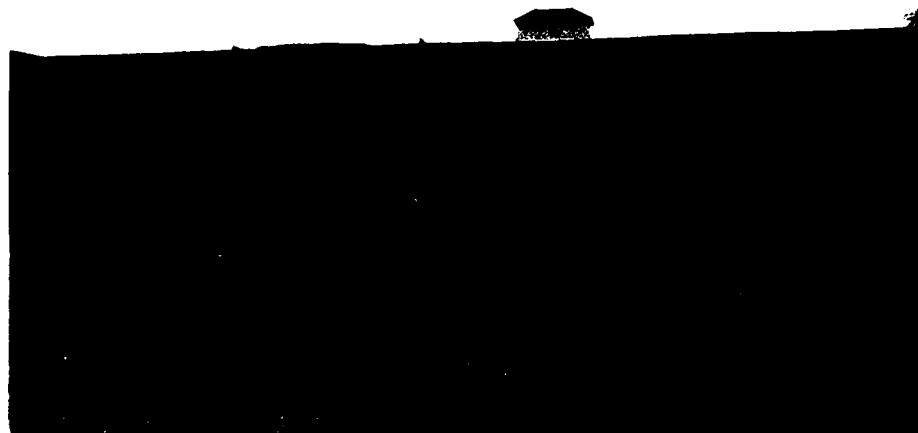


PHOTO NO. 7
VIEW OF WEST EMBANKMENT



PHOTO NO. 8
VIEW OF TYPICAL OVERFLOW ON
WEST EMBANKMENT

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MA 00528
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PHOTO NO. 9
VIEW OF WEST EMBANKMENT
LOOKING NORTH



PHOTO NO. 10
VIEW OF ACCESS DOOR TO RESERVOIRS
NO. 1 & NO. 2 ON WEST EMBANKMENT

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PHOTO NO. 11
VIEW OF EAST EMBANKMENT
LOOKING NORTH



PHOTO NO. 12
VIEW OF SEEPAGE AT BOTTOM OF
SLOPE ON EAST EMBANKMENT

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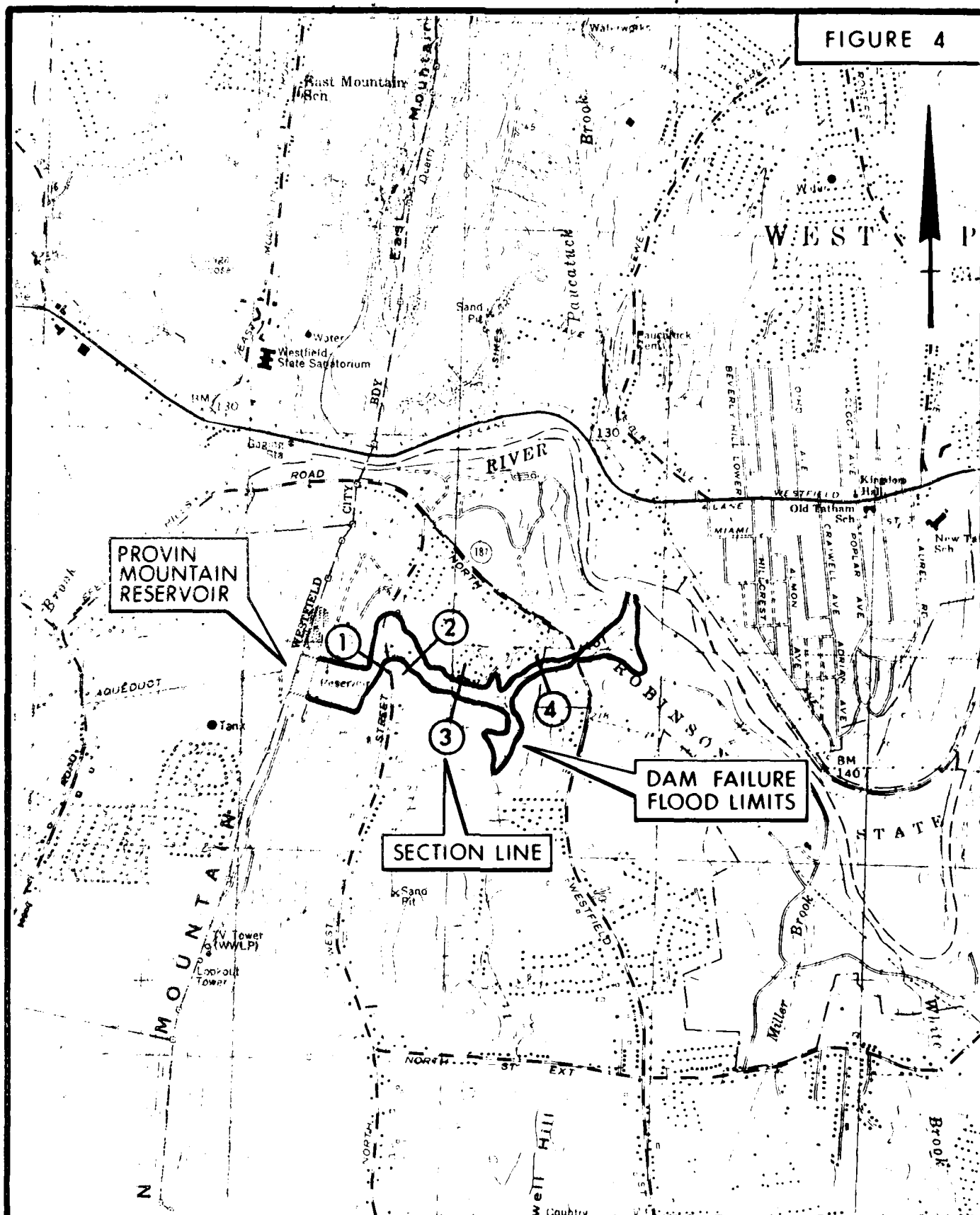
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OF NON-FED. DAMS

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City of Springfield Aqueduct
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MA 00528
March 4, 1981

APPENDIX D
HYDROLOGIC AND HYDRAULIC COMPUTATIONS

FIGURE 4



DAM FAILURE FLOOD LIMITS

PROVIN MOUNTAIN RESERVOIR
AGAWAM MASS.

1" = 2083'

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WEST SPRINGFIELD, MASS QUADRANGLE 1979

I. Classification:

SIZE: Storage (max) = 184 Ac Ft. ∴ Small

height (struct.) = 30 Ft. ∴ Small

Hazard Potential: Since Provin Mountain Reservoir sits on top of a mountain and consists of four tanks fed by an aqueduct, the installation does not have a failure outflow that is dependent upon a test flood, therefore, hazard potential will be determined based upon the downstream impact resulting from the failure of one wall on the rectangular tanks.

II. Failure Analysis:

To determine the peak failure outflow, assume failure of the east wall of both of the rectangular tanks (appears to have greatest hazard potential), producing a failure in 40% of the width of the soil outside the tanks.

Length of East wall = 600 ft. (scaled from USGS)

∴ Breach Width $W_b = 0.40 \times 600 = 240$ ft.

Assume tanks are full

∴ $Y_u = 30$ ft.

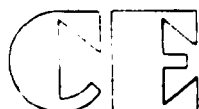
Peak Failure Outflow $Q_p = \frac{8}{27} W_b \sqrt{g} Y_u^{3/2}$

∴ $Q_p = \frac{8}{27} \times 240 \times \sqrt{32.2} \times (30)^{3/2} = 66,300$ cfs

The total capacity of all tanks is 60,000,000 gallons, therefore, at the peak failure outflow, all tanks would drain in approximately 4 minutes making it unlikely that the other tanks could be isolated following the rupture of the rectangular tanks.

∴ For downstream analysis use $S = 60,000,000$ gallons converting to Ac. Ft.:

$$S = 60,000,000 \text{ gal.} \times \frac{1 \text{ ft}}{7.48 \text{ gal}} \times \frac{1 \text{ Acre}}{43,560 \text{ sq ft}} = 184 \text{ Ac. Ft.}$$

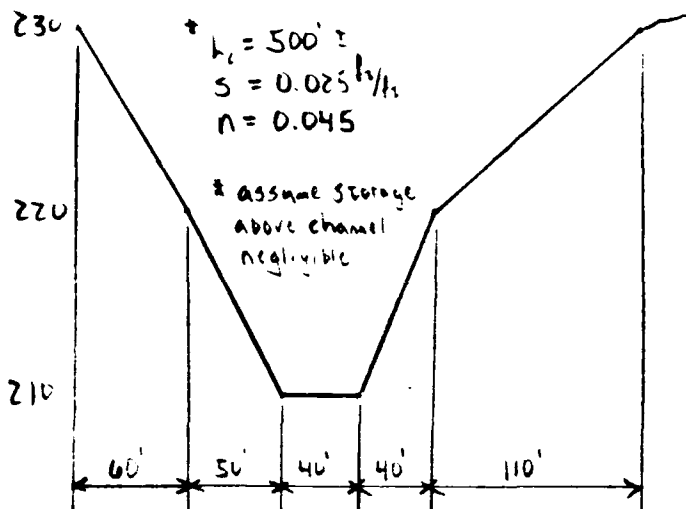


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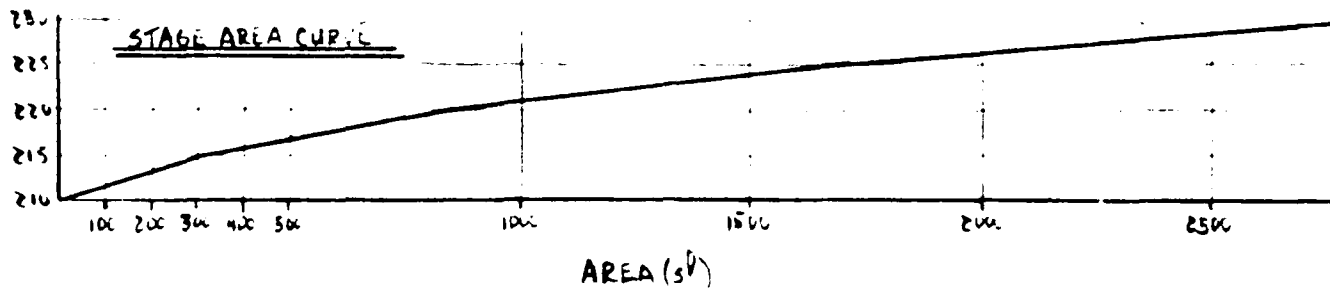
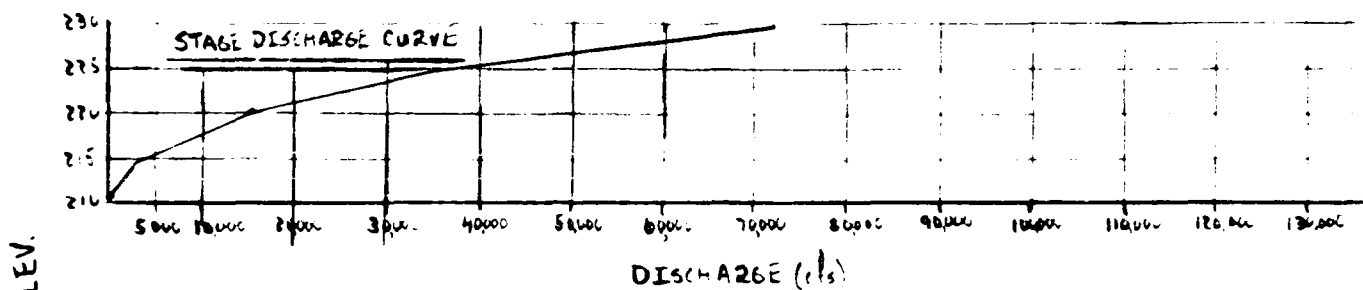
III. Downstream Failure Analysis:

Following the rupture of the tanks, the failure outflow would travel eastward down the mountain as sheet flow, most likely inundating and doing severe damage to the access road and two buildings, for approximately 800 ft. before reaching a stream channel flowing north.

① Section 1200' ± downstream of reservoir (from ASGS) $\frac{1''}{1'}$ = 100' Horiz. $\frac{1''}{1'}$ = 10' Vert.



ELEV.	A (sf)	W (ft.)	R (ft.)	$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$
215	313	86	3.63	3860 cfs
220	850	132	6.43	15,346 cfs
225	1713	212	7.87	35,387 cfs
230	3000	303	9.89	72,171 cfs



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III. Downstream Failure Analysis: cont.

$$① Q_{P_1} = 66,300 \text{ cfs}$$

$$H = 19.2 \text{ ft.} \pm (E1.229.2 \pm)$$

$$V_1 = 2795 \times 500 \times \frac{1}{43500} = 32.1 \text{ Ac. Ft.} < \frac{1}{2} S \therefore \text{Reach is OK}$$

TRIAL

$$\therefore Q_{P_{ET}} = Q_{P_1} \left(1 - \frac{V_1}{S}\right) = 66,300 \left(1 - \frac{32.1}{184}\right) = 54,742 \text{ cfs}$$

$$② Q_{P_{ET}} = 54,742 \text{ cfs}$$

$$H = 17.6 \text{ ft.} \pm (E1.227.6 \pm)$$

$$V_2 = 2390 \times 500 \times \frac{1}{43500} = 27.4 \text{ Ac. Ft.}$$

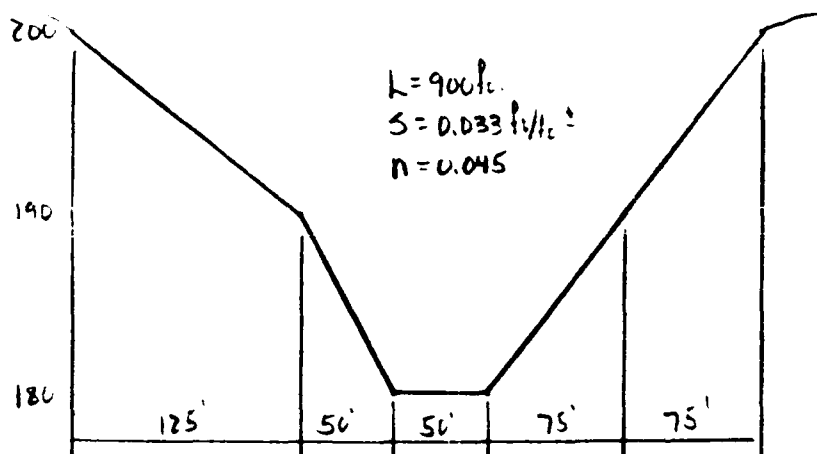
$$\therefore V_{AVG} = \frac{V_1 + V_2}{2} = \frac{32.1 + 27.4}{2} = 29.8 \text{ Ac. Ft.}$$

$$\therefore Q_{P_2} = Q_{P_1} \left(1 - \frac{V_{AVG}}{S}\right) = 66,300 \left(1 - \frac{29.8}{184}\right) = 55,574 \text{ cfs}$$

$$H = 17.7 \text{ ft.} \pm$$

$$A = 2420 \text{ sf} \pm$$

③ Section 2100' \pm downstream of reservoir (from USB) $\begin{matrix} P = 100' \text{ H.A.} \\ P = 10' \text{ V.H.} \end{matrix}$
 NOTE: Roadway will be overtopped. Assume no influence on flow

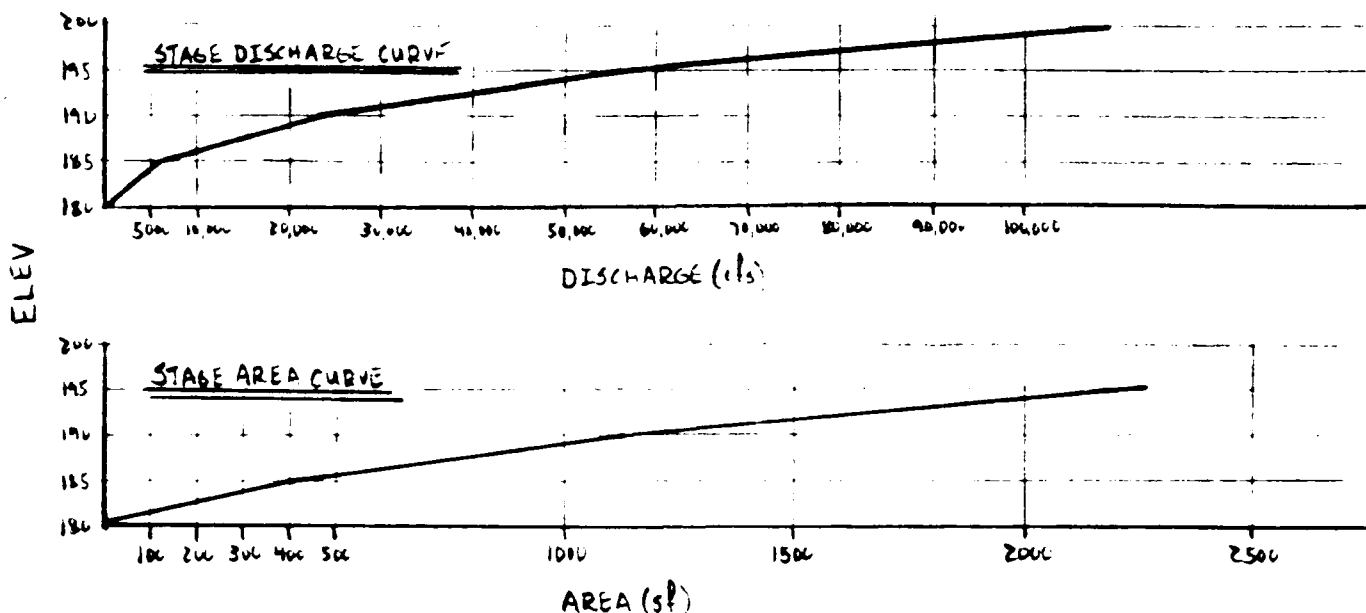


ELEV.	A (sf)	W (ft.)	R (ft.)	$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$
185	406	113	3.58	5700 cfs
190	1125	177	6.37	23,190 cfs
195	2250	278	8.11	54,483 cfs
200	3875	378	10.2	109,329 cfs

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III. Downstream Failure Analysis: cont.



② $Q_{p_2} = 55,574 \text{ cfs}$
 $H = 15.1 \text{ ft} \pm (\text{El. } 195.1 \pm)$
 $V_1 = \frac{2420 + 2280}{2} \times 900 \times \frac{1}{43500} = 48.6 \text{ Ac. Ft.} < \frac{1}{2} S \therefore \text{Remain is OK.}$

TRIAL
 $\therefore Q_{p_{2T}} = Q_{p_2} (1 - \frac{V_1}{S}) = 55,574 (1 - \frac{48.6}{184}) = 40,909 \text{ cfs}$

③ $Q_{p_{3T}} = 40,909 \text{ cfs}$
 $H = 12.8 \text{ ft} \pm (\text{El. } 192.8 \pm)$
 $V_2 = \frac{2420 + 1700}{2} \times 900 \times \frac{1}{43500} = 43.2 \text{ Ac. Ft.}$

$\therefore V_{\text{AVE}} = \frac{V_1 + V_2}{2} = \frac{48.6 + 43.2}{2} = 45.9 \text{ Ac. Ft.}$

$\therefore Q_{p_3} = Q_{p_2} (1 - \frac{V_{\text{AVE}}}{S}) = 55,574 (1 - \frac{45.9}{184}) = 41,713 \text{ cfs}$ $H = 13.0 \text{ ft.} \pm$ $A = 1790 \text{ sf.} \pm$

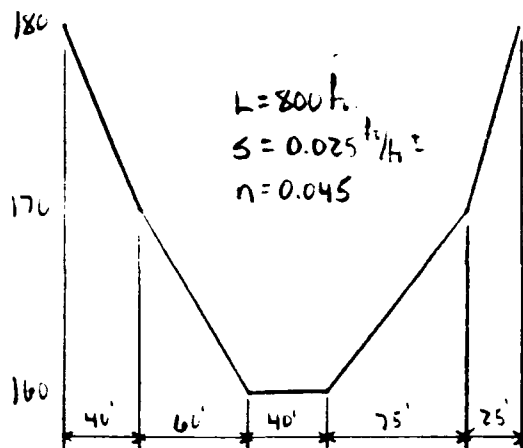
Assuming a constant water surface slope between the first two sections, the roadway (North West Sec.) would be overtopped by 8 to 9 ft \pm and at least 2 buildings in a residential area would be damaged.



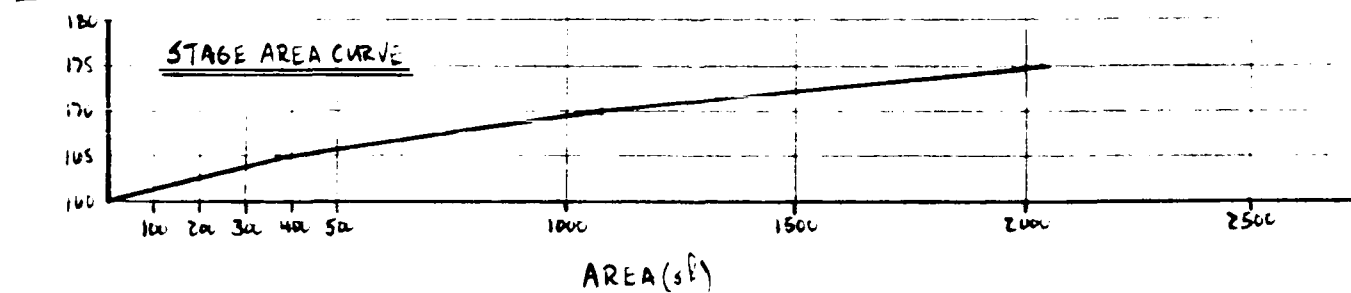
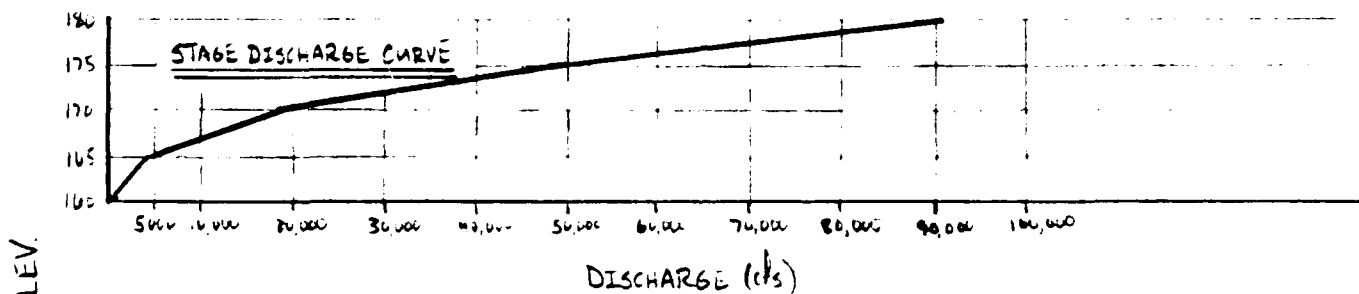
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III. Downstream Failure Analysis, cont.

③ Section 2900 ft. downstream of reservoir (from USGS) $\frac{1''=100' \text{ H.}}{1''=10' \text{ V.}}$



ELEV.	A (sf)	W (ft)	R (ft)	$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$
165	369	108	3.41	4365 cfs
170	1075	176	6.04	18,718 cfs
175	2031	210	9.67	48,132 cfs
180	3150	244	12.9	90,465 cfs



③ $Q_{P_3} = 41,173 \text{ cfs}$

$H = 13.8 \text{ ft.} \pm (E1.173.8 \pm)$

$V_1 = \frac{1740+1805}{2} \times 800 \times \frac{1}{43500} = 33.0 \text{ Ac. Ft.} < \frac{1}{2} S \therefore \text{Remains OK}$

TRIAL

$\therefore Q_{P_{HT}} = Q_{P_3} \left(1 - \frac{V}{S}\right) = 41,173 \left(1 - \frac{33.0}{184}\right) = 33,786 \text{ cfs}$



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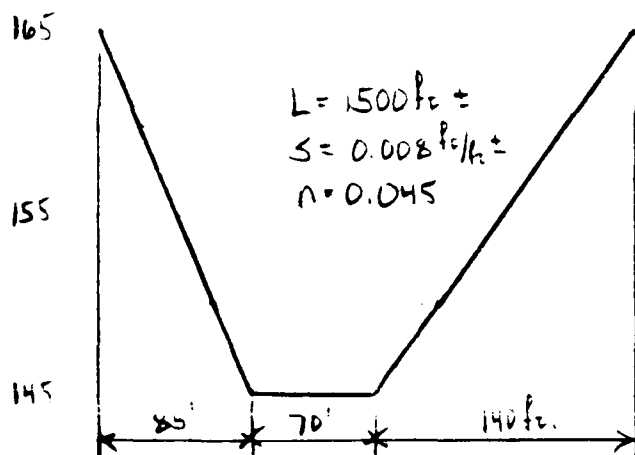
III. Downstream Failure Analysis: cont.

$$\begin{aligned} @ Q_{P_4} &= 33,780 \text{ cfs} \\ H &= 12.6 \text{ ft.} \pm (E1.172.6 \pm) \\ V_2 &= \frac{1740 + 1565}{2} \times 800 \times \frac{1}{43560} = 30.8 \text{ Ac. Ft.} \end{aligned}$$

$$\therefore V_{ave} = \frac{V_1 + V_2}{2} = \frac{33.0 + 30.8}{2} = 31.9 \text{ Ac. Ft.}$$

$$\therefore Q_{P_4} = Q_{P_3} \left(1 - \frac{V_{ave}}{S}\right) = 41,173 \left(1 - \frac{31.9}{184}\right) = 34,034 \text{ cfs} \quad \begin{matrix} H = 12.6 \text{ ft.} \pm \\ A = 15753 \text{ ft}^2 \end{matrix}$$

- ④ Section 4400 ft. \pm downstream of reservoir (from 4565) $\begin{matrix} 1'' = 100' \text{ HORIZ.} \\ 1'' = 10' \text{ VERT.} \end{matrix}$
 NOTE: Base flow in channel neglected since peak failure outflow is not directly related to rainfall

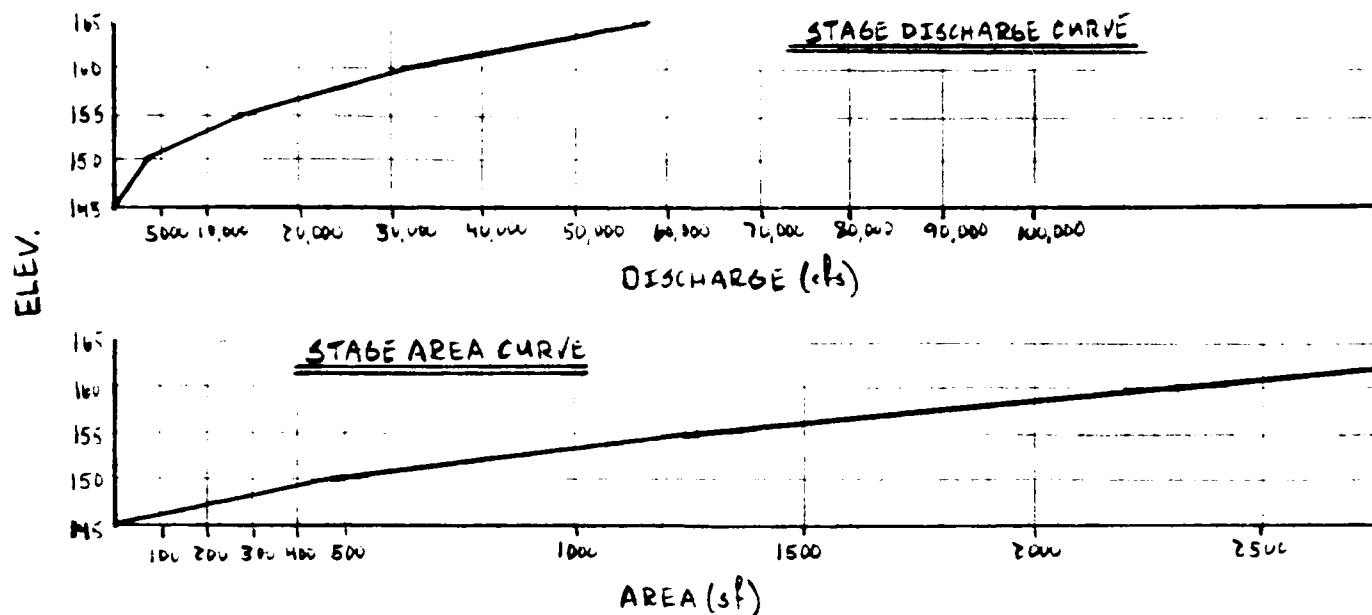


ELEV.	AREA	WETTED PERIMETER	HYDRAULIC RADIUS	$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$
150	4913	126 ft	3.89 ft.	3587 cfs
155	1263	183	6.92	13,546
160	2316	239	9.70	31,113
165	3650	295	12.4	57,755



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III. Downstream Failure Analysis: cont.



① $Q_{P_H} = 34,034 \text{ cfs}$
 $H = 15.5 \text{ ft.} \pm (E1.160.5 \pm)$
 $V_1 = \frac{1575 + 2465}{2} \times 1500 \times \frac{1}{43,500} = 70 \text{ Ac. Ft.} < \frac{1}{2} S. \therefore \text{Pench is OK}$

TRIAL
 $\therefore Q_{P_{ST}} = Q_{P_H} \left(1 - \frac{V_1}{S}\right) = 34,034 \left(1 - \frac{70}{124}\right) = 21,168 \text{ cfs}$

② $Q_{P_{ST}} = 21,168 \text{ cfs}$
 $H = 12.2 \text{ ft.} \pm (E1.157.2 \pm)$
 $V_2 = \frac{1575 + 1720}{2} \times 1500 \times \frac{1}{43,500} = 57 \text{ Ac. Ft.}$

$\therefore V_{AVG} = \frac{V_1 + V_2}{2} = \frac{70 + 57}{2} = 63.5 \text{ Ac. Ft.}$

$\therefore Q_{P_S} = Q_{P_H} \left(1 - \frac{V_{AVG}}{S}\right) = 34,034 \left(1 - \frac{63.5}{124}\right) = 22,289 \text{ cfs } (H = 12.5 \pm)$

At this elevation, North Westfield S. would be overtopped by 4 to 5 ft. due to the peak failure outflow. Approximately 2000 ft. downstream of this section, the flow would be attenuated by Dr. Westfield River.



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IV. Summary:

Rupture of the dams for Piccola Mountain Reservoir will cause flooding downstream (east of the reservoir) with flow depths in the channel generally averaging 10 to 15 ft. Extreme damage (including possible loss of life) will occur to two buildings at the reservoir site and at least two residential structures. In addition, North West St. and North Westfield St. would both be overtopped before the failure outflow would be attenuated by the Westfield River. The hazard potential, therefore, is High.

The pre-failure flow depths and the depths following failure in the downstream channel are as follows:

<u>Section</u>	<u>* Pre-Failure Depth</u>	<u>Depth Following Failure</u>
1	* 0 ft. \pm (El. 210.0 \pm)	17.7 ft. \pm (El. 227.7 \pm)
2	0 ft. \pm (El. 190.0 \pm)	13.0 ft. \pm (El. 193.0 \pm)
3	0 ft. \pm (El. 160.0 \pm)	12.6 ft. \pm (El. 172.6 \pm)
4	0 ft. \pm (El. 145.0 \pm)	12.5 ft. \pm (El. 157.5 \pm)

* Since there is no overland flow resulting from reservoir outflow, it is assumed that the flow depth downstream, prior to failure, is 0 ft.

Based upon the results of the downstream failure analysis, the failure outflow would overtop North West Street by 8 to 9 ft., would cause flow depths of 5 to 10 ft. at at least two residential structures, and would overtop North Westfield St. by approximately 10 ft. Also, at least one building on the reservoir would receive damage due to the street flow and several homes adjacent to the stream may receive 1 to 2 ft. of water. The soil elevations of the two roads are approximately 200 and 205, the expected post failure water surface elevation is approximately 210 at the houses.

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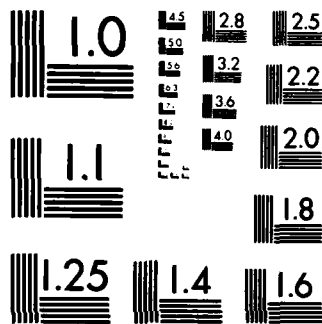
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APPENDIX E

INFORMATION AS CONTAINED IN
THE NATIONAL INVENTORY OF DAMS

NOT AVAILABLE AT THIS TIME

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